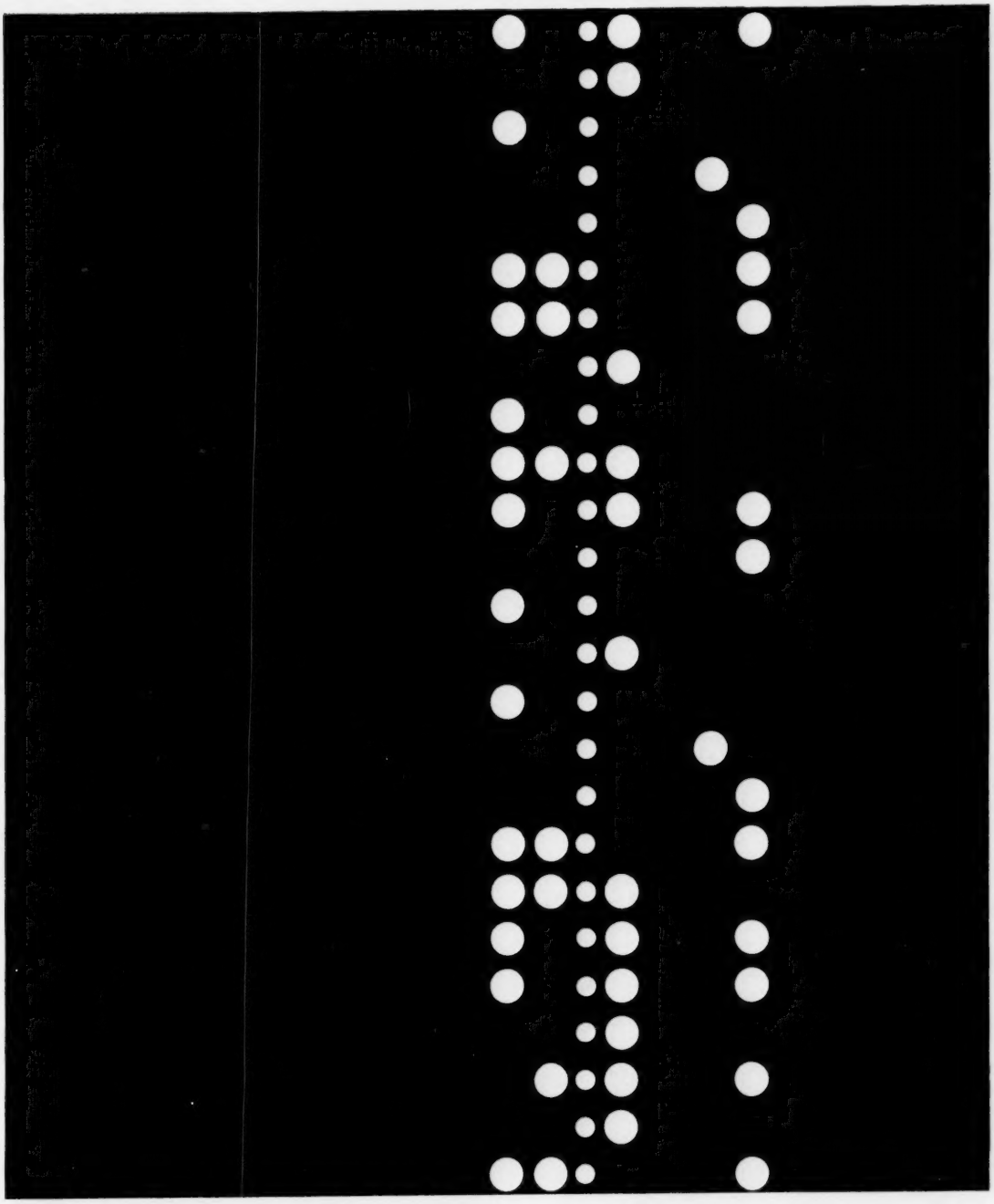
INSTRUMENTS AND CONTROL SYSTEMS

SEPTEMBER 1961 JOURNAL OF THE SCMA • PRECISION MEASUREMENTS ASSOCIATION • SIMULATION COUNCIL NEWSLETTER



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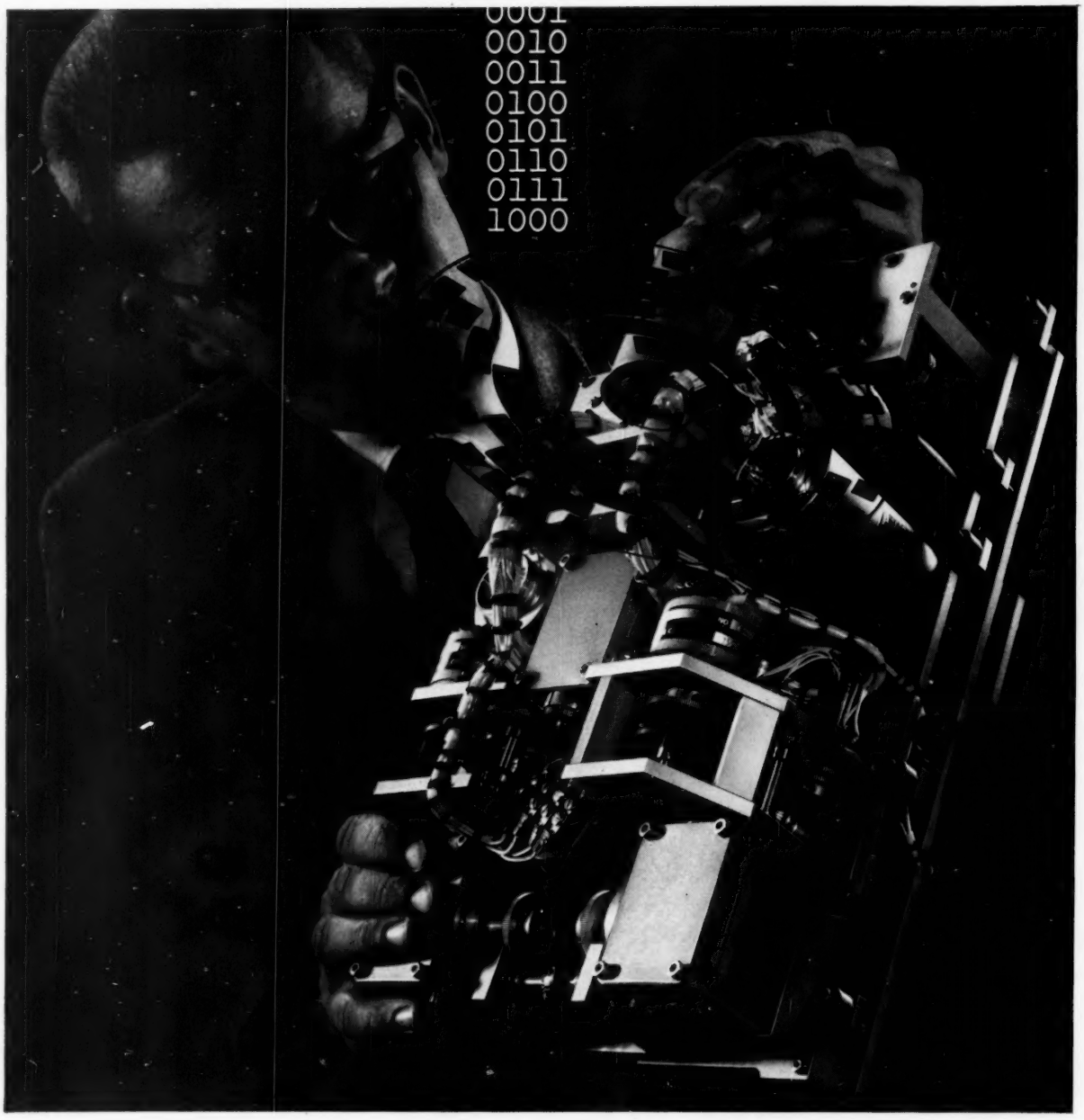

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CIRCLE 1 ON READER-SERVICE CARD

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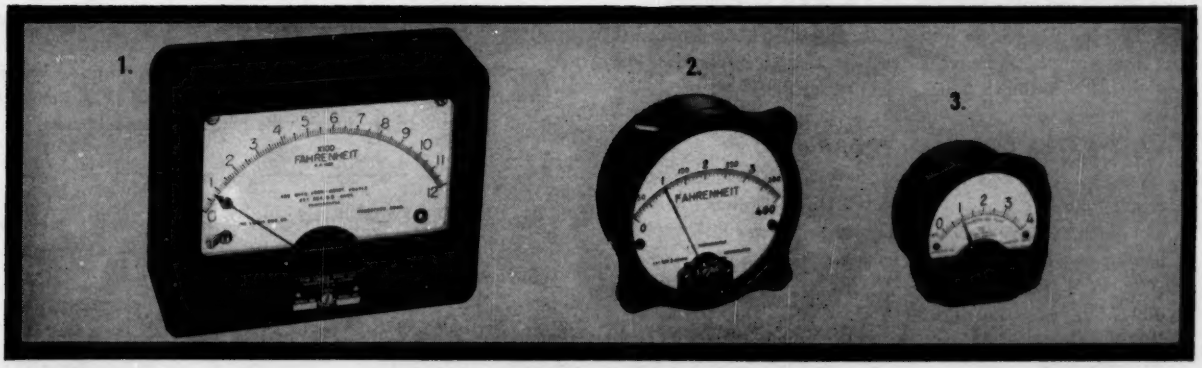

THE LEWIS ENGINEERING CO.
NAUGATUCK, CONNECTICUT

*Hoskins TM.

CIRCLE 2 ON READER-SERVICE CARD

A CASE OF *Accuracy!*

The "COMMANDER" instruments described below have a 5-year accuracy guarantee. By using NBS or NRC reported values, total cumulative errors for a complete measurement system can be as low as ±.002%.

DAUPHINEE POTENTIOMETER TYPE 9144

ACCURACY ±.001%

A new 6-figure DC vernier potentiometer with a total measuring range of 2.101010V. *Accuracy is at least 10 x that of similar commercially available equipment.* Direct readout on 4 dials in increments of .1 μv (no slidewire). Thermal emf's less than .1 μv. Switch controlled ranges of x 1 & x .1. Contains 2 saturated standard cells in an internally thermostatted enclosure. Completely "Self-Checking." *May be used with equal facility and accuracy as a Saturated Standard Cell or Resistance Comparator — and for the calibration of .01% accurate potentiometers.*

The Type 9144 is an original design by Dr. T. M. Dauphinee of the National Research Council in Canada. All rights are protected by a United States patent application.

VOLT RATIO BOX TYPE 9700A

ACCURACY ±.005%

A volt ratio box similar to that used by the National Bureau of Standards as described by NBS Research Paper RP 1419. Self-heating and surface leakage negligible. Ranges: .15/.3/.45/.6/.75/1.5/3/4.5/6/7.5/15/30/45/60/75/150/300/450/600/750/900/1050/1200/1350/1500 V. (Type 9700 up to 750 V. only). Furnished in a thermostatted oil bath with a motor-driven impeller.

CONSTANT TEMPERATURE STANDARD CELL ENCLOSURE TYPE 9152 AND SATURATED STANDARD CELL TYPE 4305

ACCURACY ±.001%

Enclosure accommodates up to 4 cells and is air thermostatted at 30°C ± .01°C. Transistorized circuit. Operates on 110V/60 cps (Battery standby). Type 9152A holds 12 cells.

THE TYPE 5214 GALVANOMETER AMPLIFIER AND TYPE SR21 LIGHT SPOT GALVANOMETER

The amplifier operates on the differential photocell principle in conjunction with a liquid-filled primary galvanometer. The secondary galvanometer has a scale length of 120-0-120 mm and is stable and free from the effects of external vibration. Over-all sensitivity is approximately 350,000 mm/μa and 52,000 mm/μv. It is ideally suited for use with the type 9144 potentiometer.

Sensitive Research "COMMANDER" Instruments are manufactured by Guildline Instruments, Ltd. (formerly Tinsley Instruments (Canada) Ltd.)

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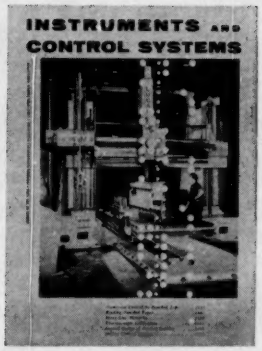
NEW ROCHELLE, N. Y.

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS



A numerically controlled machine tool emphasizes this month's subject of major emphasis—numerical control and punched-tape techniques.

VOLUME 34, NUMBER 9, SEPTEMBER 1961

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THIS MONTH
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INSTRUMENTS AND CONTROL SYSTEMS; INSTRUMENT & APPARATUS NEWS; MILITARY SYSTEMS DESIGN; MEDICAL ELECTRONIC NEWS

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HOKE Flow Sheet 7

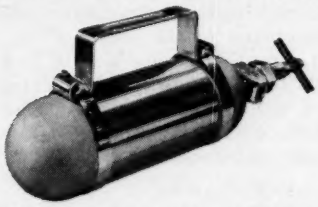
HOKE REPORTS ON FLUID CONTROL

PRESSURE BY THE POUND... no matter how thin you slice it!

Do You Have A Bomb In Your Lab?

In the process industry, sampling cylinders are occasionally referred to as bombs. In recent months, this misnomer has been, unhappily, pretty close to the truth. Some military surplus, low carbon steel, two-piece cylinders have found their way into industry and have been used beyond their rather limited capabilities. Unfortunately, several serious accidents have spotlighted this use as a very real safety problem.

Since sampling is such a serious business, we have perfected, for maximum safety, a seamless, one-piece cylinder. This unabashed declaration of excellence has sound

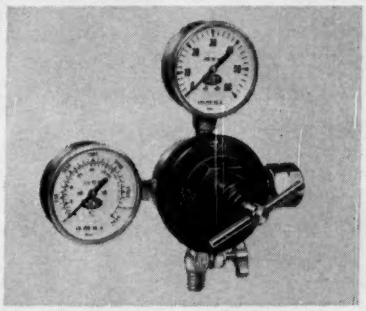


basis in fact – the entire cylinder is formed from a single piece of seamless type 304 stainless steel tube. To quell the qualms of process men, sample contamination is practically nonexistent, and the cylinder resists destruction from most corrosives.

As a further safety guarantee, all standard sampling cylinders are fabricated to meet ICC and other safety regulations. Standard cylinders are available at pressures to 1800 psi (10 ml. to 1 gallon), but higher pressure cylinders can be had on special order.

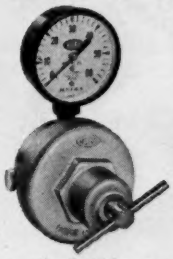
If you'd like additional information on Hoke cylinders, plus a detailed paper on the various methods of collecting samples from process lines, drop us a line. We'll also include details on special cylinder valves, outage tubes and other cylinder accessories.

One trouble with doing something better is that it's hard to stop. This time, we've come up with a new line of pressure regulators. We made them for the technically oriented who have developed high standards and for the penurious purchaser who wants something for (almost) nothing.



One, tagged as the 680 Series, is a highly stable single stage regulator with something for just about everyone. The core of this regulator is its control accuracy of 2% at flows to 2000 SCFH. Two models are available. One delivers 0 to 40 psi and the other 0 to 140 psi and both can handle inlet pressures up to 3000 psi. Use them on any gas compatible with 2024-T4 aluminum alloy, neoprene, polyurethane and Buna-N.

If what we've said sounds good so far, but still won't solve your problems, read on.



We've built a regulator specially for corrosive gases and atmospheres. Available in either all monel or all stainless steel construction, we call it the 640 Series. Spec sheets on this can be had by marking an "X" below.

If you "X" the next box, you'll get a package of useful information on a special regulator that will handle delivery pressures up to 4500 psi with

very high control accuracy. This is a 2 stage spring and dome loaded regulator and we claim that a 50% change in inlet pressure will not change the delivery pressure more than 2%. Operation is simplicity itself. For no particular reason, we call this the 920 Series.

Skeptics should send for all of this information.

'61 PRODUCT PARADE

You'd be surprised at some of the screwball ways our valves have been used (to decided advantage, of course). Hoke distributors are armed to their maxillary third molars with this method madness and will redesign your systems with new Hoke products at the drop of a postcard. Check the PRODUCT PARADE Box.

Hoke's Performance Guarantee—*Every Valve Leak-Tested!*

HOKE INCORPORATED
31 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ 680 Series Regulator
- ☐ 640 Series Regulator
- ☐ 920 Series Regulator
- ☐ '61 Product Parade
- ☐ Sampling Cylinders
- ☐ Complete Catalog GC561

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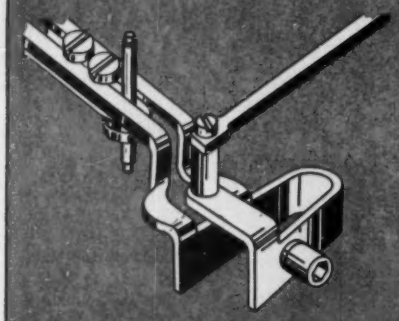
SEE OUR CATALOG IN SWEETS PRODUCT DESIGN FILE

CIRCLE 4 ON READER-SERVICE CARD

HEISE GAUGES

MICRO-SLIDE



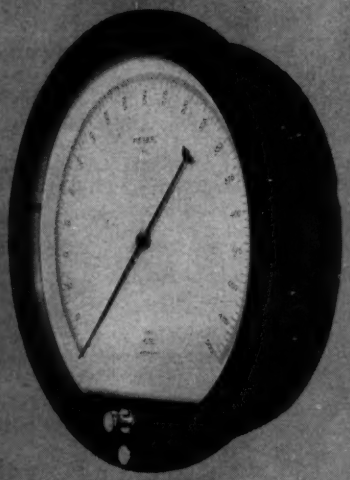
Highly favorable reaction among gauge users has followed the development of the Heise Micro-Slide adjustment. Systematic field recalibration of batteries of Heise gauges may now be directly and precisely effected with minimum time loss.

Calibration adjustments as fine as .0005 inches in the effective length of the sector slide may be quickly and conveniently applied.

Periodic recalibration of gauges may also be reduced as a result of the damping effect of the spring loaded adjustment which protects the setting from shock and vibration.

CONVENIENT PRECISION RECALIBRATION

The Micro-Slide comprises a spring loaded micrometer screw controlling the position of the link pivot. This screw may be conveniently adjusted with a standard Allen wrench. A flat spring cushions the assembly and protects the setting from sheck or vibration.



Dial Sizes	FULL SCALE READING (P.S.I.)						
	0-15 to 0-5,000 inclusive	Over 0-5,000 and including 0-20,000	Over 0-20,000 and including 0-30,000	0 to 40,000	0 to 50,000	0 to 75,000	0 to 100,000
8½"	$183.50	$205.50	$238.50				
12"	$209.50	$231.50	$264.50	$275.50	$286.50	$336.50	$386.50
16"	$255.50	$277.50	$310.50	$321.50	$332.50	$382.50	$432.50

DELIVERY — 2 WEEKS FOR MOST RANGES — PRICE F.O.B. NEWTOWN

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BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

CIRCLE 5 ON READER-SERVICE CARD

LETTERS TO THE EDITOR

Editor, I&CS:

I just received a copy of "Twelve Special Project Reports on Instruments and Controls." This single document represents one of the most useful publications that I have had the opportunity to review recently. My sincere thanks for the privilege of having a personal copy.

Andreas B. Rechnitzer
Deep Submergence Research
Program Coordinator
U.S. Navy Electronics Laboratory
San Diego, Calif.

Editor, I&CS:

In response to a reader's request for information about an instrument for measuring relative humidity, I have been . . . designing a "vest-pocket" electronic humidity sensor. It will be entirely transistorized and self-contained, essentially amplifying the current from an AC bridge, one leg of which is a miniature "water-of-adsorption" sensor, and feeding this to a sensitive DC meter. Theoretically, it should be able to read to an accuracy of ± 2 to 4% with a tolerance somewhat less (aproximately the characteristics of the sensor itself). Other types of sensors also will be able to be used with this instrument . . . I need to take the unit *below* the surface into caves for ecological-physiological studies.

Robert E. Henshaw
Department of Physiology
Iowa State University of Medicine
Iowa City, Iowa

Editor, I&CS:

I am one of those who like to tear out the articles which are of particular value to me. The articles are then filed by subject. However, when the first page of one article is printed on the back of the last page of another, my filing system breaks down. My suggestion is therefore that you start all articles on odd-numbered pages, sticking an ad between the articles if necessary.

Please do not take offense that I tear up your fine magazine; it is the only solution I have found for my personal information storage and retrieval problem.

Erik Wiik
Ponca City, Okla.

We will try—see the articles in this issue.

Editor, I&CS:

Referring to Mr. Smith's comments (published in July *I&CS*) on the article, "Ceramic Insulated Thermocouples," (published in the May issue of *I&CS*), we would like to reply as follows:

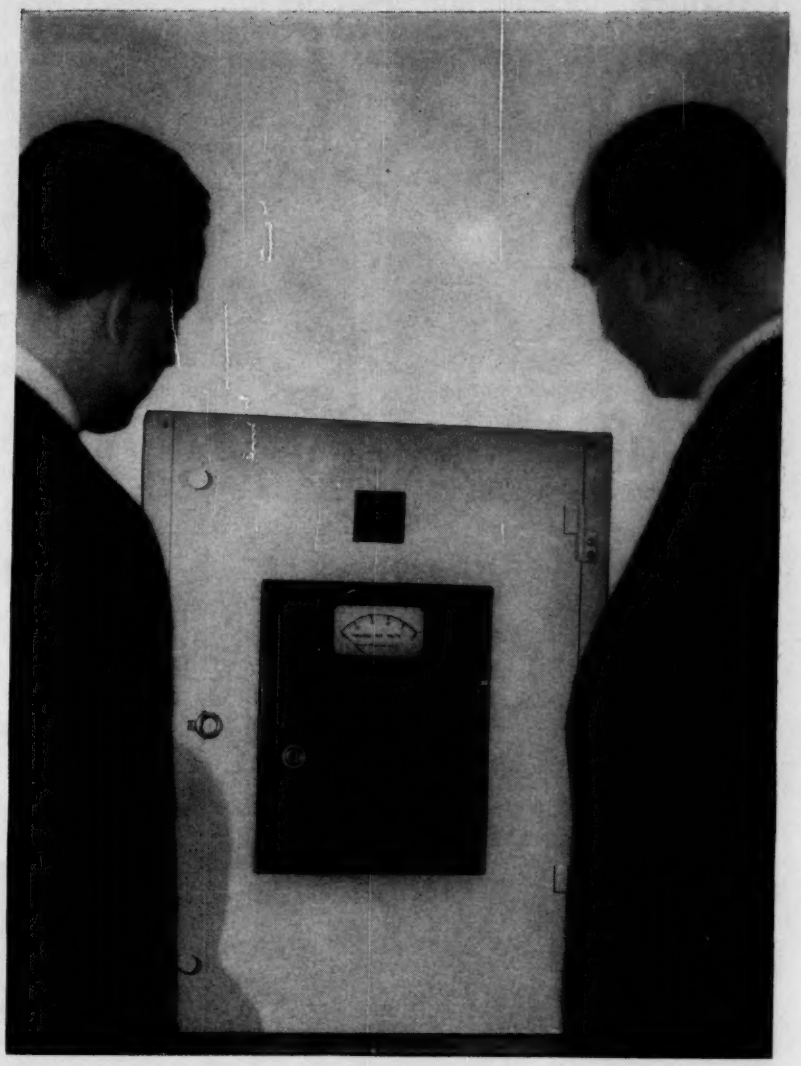
The ±1°F accuracy was not "readily obtained," but we were able to do it, which is the point. The microvolt homogeneity check is expensive to run as a test. The "major user" Mr. Smith refers to estimates the cost at $1.00 per foot, but it was left unsaid in our article that AerOpak is supplied with homogeneity differences of less than 100 microvolts and the same "major user" on a recent test found our AerOpak was running less than 40 microvolts deviation —at no extra charge!

There may be "excellent technical reasons" for higher calibration deviation as Mr. Smith claims, but our actual production evidence, as mentioned above, and in that article, belies his statement.

It will be hard for a great number of users of AerOpak conductors who have used stainless sheath and copper wires to believe that the wire was damaged by our processing. Stainless and copper can be annealed together without damage to the copper provided the time, temperature and cooling rate are regulated correctly. I must infer from Mr. Smith's comments that his SPS process leaves the stainless sheath in the cold-worked condition, subject to fracture if it is formed on a tight radius. AerOpak is fully annealed with ductile wire.

One of the major development expenses in using multiple-pass drawing techniques is learning about the metallurgical properties of many materials. Proper heat treatments that satisfied both the sheath and conductors had to be developed. Correct reduction ratios combined with the proper heat treatments also had to be evolved. When ARi actually started manufacturing AerOpak material, it used the single-pass swaging technique. With the decision to advance to multiple-pass drawing (as all tubing mills and wire-drawing concerns now do), we had to re-invest our profits into developing this process. Users of single-pass swaging are apparently reluctant to do this.

L. Scadron
Aero Research Instrument Co., Inc.
Chicago, Ill.



"a complete, low-priced flow-control system in this cabinet?"

"yep . . . and with rate-of-flow indication, totalization and 2% accuracy!"

But, that's not the complete story on the Hays Model 371 Veritrol—it handles fluids like molasses, oils, acids, etc. . . . it uses the proved positive displacement meter . . . it can be used in the blending of two miscible fluids.

Get the complete story in specification B347/371

THE hays CORPORATION • MICHIGAN CITY, INDIANA

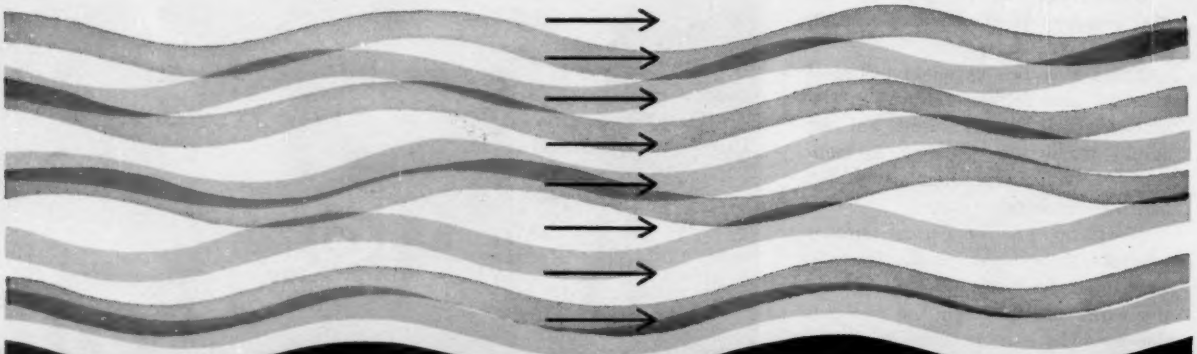
CIRCLE 6 ON READER-SERVICE CARD

Honeywell announces the NEW series 1400 low flow control valve

The addition of the new Series 1400 valve body to the Honeywell line of control valves now gives you a choice of actuator-body combinations to match your applications. Now you can choose the exact type and degree of control you need, without pushing a valve beyond its design limits . . . or without paying for more performance than you need.

The compact Series 1400 valve body is available in a full range of materials, ratings and sizes, with screwed or flanged ends. It can be used to regulate small flows in process, pilot plant, research and commercial control systems. Each body size (½", ¾" and 1") has a wide range of reduced ports with Cv's from .025 to 11.0. Two bonnet constructions facilitate mounting of five types of actuators —three pneumatic and two electric.

Each actuator-body combination fits a different range of operating conditions and performance characteristics, but with sufficient overlapping of these ranges to give you a wider selection on the basis of cost. For complete details, write for Bulletin B803-1. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.



Model 1401 Low Flow Valve with heavy-duty pneumatic actuator for systems requiring high shut-off ratings and accurate valve positioning.

Model 1403 Low Flow Valve with compact, light weight pneumatic actuator for average industrial and commercial control systems.

Model 1404 Low Flow Valve with reduced port Cv's to .025 and top-mounted positioner integral with pneumatic actuator.

Model 1406 Low Flow Valve with *Modutrol* capacitor-type, electric motor actuator for two-position, floating or proportional control.

Model 1407 Low Flow Valve with heavy-duty *Actionator* electric motor actuator provides more power for higher valve shutoff ratings.

Honeywell

H First in Control

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 7 ON READER-SERVICE CARD

Editor, I&CS:

The article on "Self-Qualification of Laboratories" which you reprinted in summary form in the July issue of *INSTRUMENTS AND CONTROL SYSTEMS* is stimulating a considerable amount of discussion and comment in many quarters. We are grateful for your bringing it to the attention of your readers.

A. T. McPherson
Associate Director
National Bureau of Standards
Washington 25, D.C.

Editor, I&CS:

I have read Mr. C. R. Townsend's article in the current issue, (July, page 1266-67) on the subject of "Fresh Water From the Sea." Please accept my congratulations for a good descriptive article.

I have developed a proposed flow diagram of a system whereby nuclear energy is first converted into steam, then passing through a conventional power plant cycle, converting the energy into electric power, which in turn can be used to produce other valuable products. The feature is the conversion of sea water, using the steam energy to produce the remaining cycle. Many plants have been built using nuclear energy to produce power by conventional methods. I believe this is the first proposal to use the steam from sea water to produce power. The installation can be automatic by use of instruments and control systems.

I have had fifty years' experience in building and operating large steam plants. This, coupled with my recent 45 days work on Wake Island (in the Mid Pacific) where I drank and bathed with Evaporated Sea Water, has made me completely absorbed in the subject.

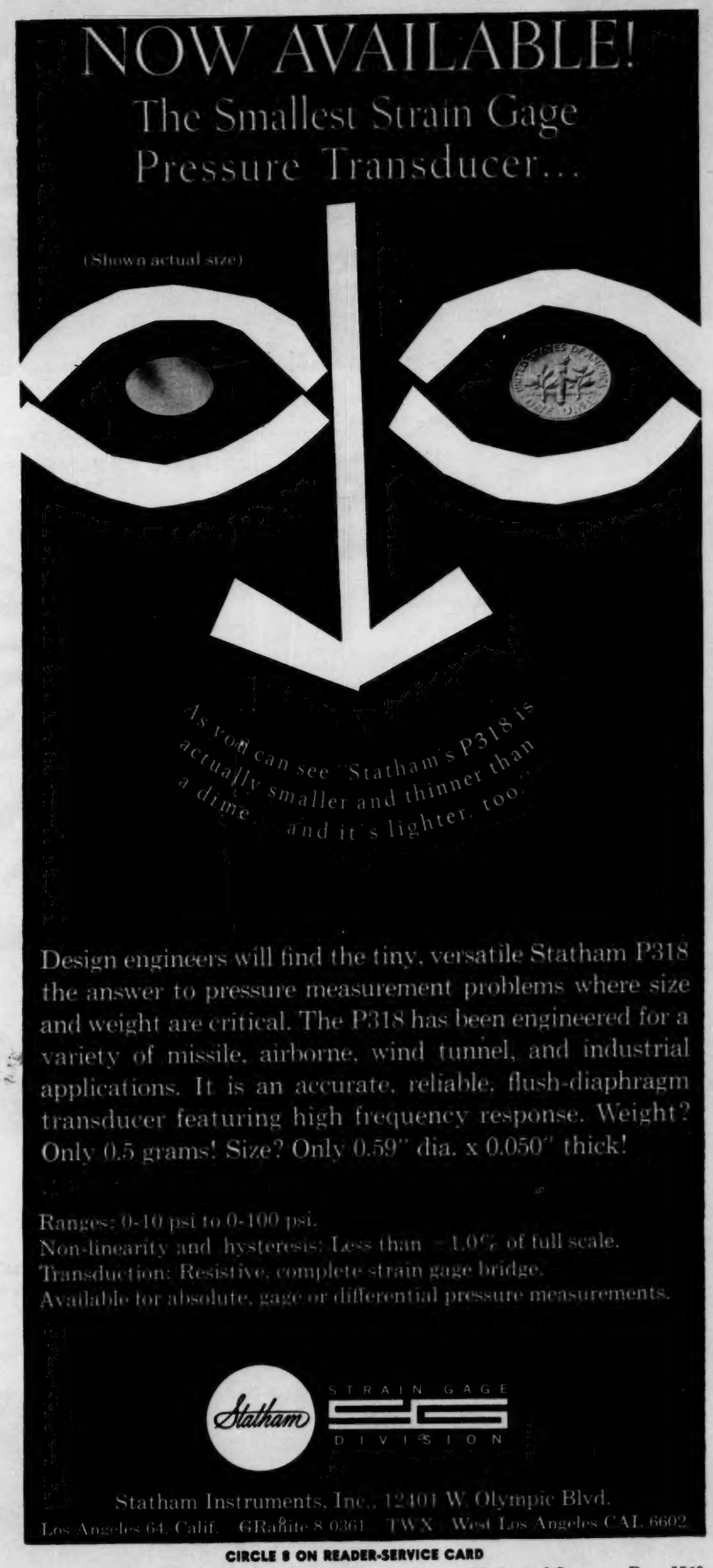
W. R. Pender
633 *Crosswinds Courts*
4125 *Park St. North,*
St. Petersburg 9, Fla.

Editor, I&CS:

There is an error in the July issue, Page 1235, referring to the Kelvin and Hughes Processor. Projector provides negative large screen displays in 2½ seconds, positive reversal images in 4½ seconds; color images in 20 seconds.

J. Hopwood
Kelvin Hughes, America Corp.
Annapolis, Md.

(*Continued on page* 1565)


NOW AVAILABLE!
The Smallest Strain Gage Pressure Transducer...
(Shown actual size)
As you can see Statham's P318 is actually smaller and thinner than a dime... and it's lighter, too.
Design engineers will find the tiny, versatile Statham P318 the answer to pressure measurement problems where size and weight are critical. The P318 has been engineered for a variety of missile, airborne, wind tunnel, and industrial applications. It is an accurate, reliable, flush-diaphragm transducer featuring high frequency response. Weight? Only 0.5 grams! Size? Only 0.59" dia. x 0.050" thick!
Ranges: 0-10 psi to 0-100 psi.
Non-linearity and hysteresis: Less than ± 1.0% of full scale.
Transduction: Resistive, complete strain gage bridge.
Available for absolute, gage or differential pressure measurements.
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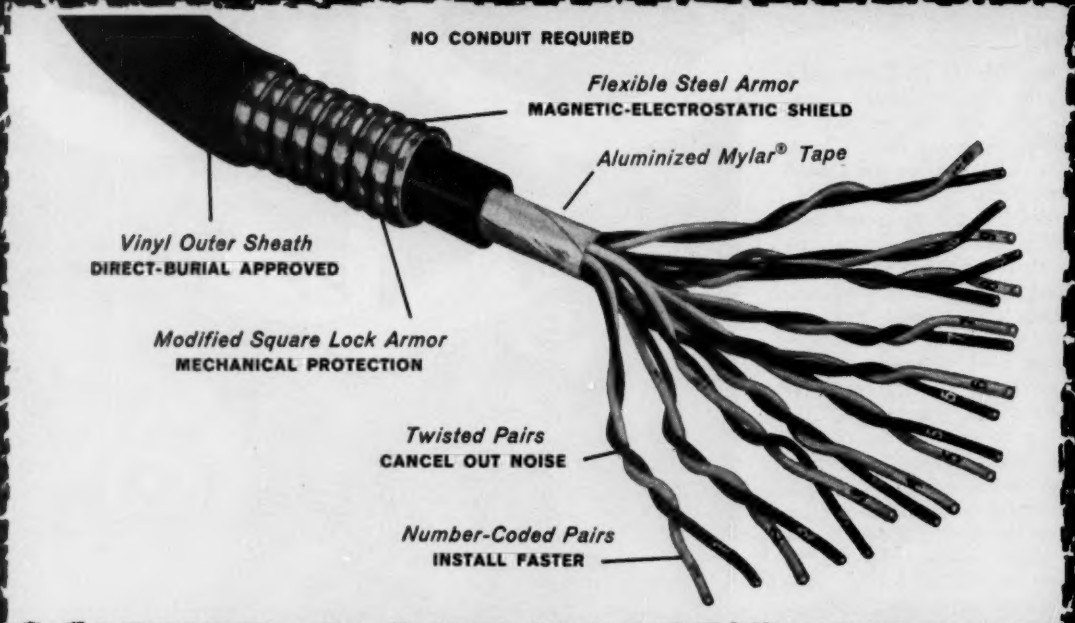
CIRCLE 9 ON READER-SERVICE CARD

DEKORON TYPE "AT" MULTICOUPLE EXTENSION WIRE WITH MAGNETIC SHIELD *keeps your process up to par years longer.*

Other advantages of Dekoron Type AT include easier installation . . . greater resistance to crushing, chemical and moisture attack for lowest maintenance. Always specify Dekoron products for maximum performance with minimized cost.



Dekoron New Metl-Cor combines exclusive parallel tubes of copper or aluminum with polyethylene protective sheath. Lack of "corkscrew effect" speeds installation. Dekoron also offers a full line of metal-armored tubing harnesses.

Dekoron Protecto-Pac (Type FB shown), an all-plastic harness with high resistance to weld splash, sparks, flash fires, etc. Dekoron Poly-Cor (not shown) has number-coded polyethylene tubes, Mylar® vapor barrier, flexible vinyl outer sheath.

Dekoron® products

quality • research • service

SAMUEL MOORE & COMPANY • DEKORON PRODUCTS DIVISION • MANTUA, OHIO

Editor, I&CS:

I enjoyed reading your article "Filled System Thermometers" in the 1961 issue of INSTRUMENTS AND CONTROL SYSTEMS. However, after studying Table 1, "Basic Features of Filled Thermal Systems," I am somewhat confused about elevation errors listed under disadvantages.

As I understand it, a Class I (liquid) and Class V (mercury) system in most cases have an insignificant error. The reason is that the system is one dependant upon a volumetric change of the thermal fluid—not pressure. However, in a Class II system (vapor pressure), the elevation error is critical since the element senses a pressure change. Any deviation in elevation will affectively change the pressure within the thermal system and thereby give an erroneous reading. Of course, compensation is accomplished very easily since it is only a zero shift.

Your comments will be appreciated.

T. R. Merlihan,
Instrument Engineer
Durez Plastics Div.
Hooker Chemical Corp.
N. Tonawanda, N. Y.

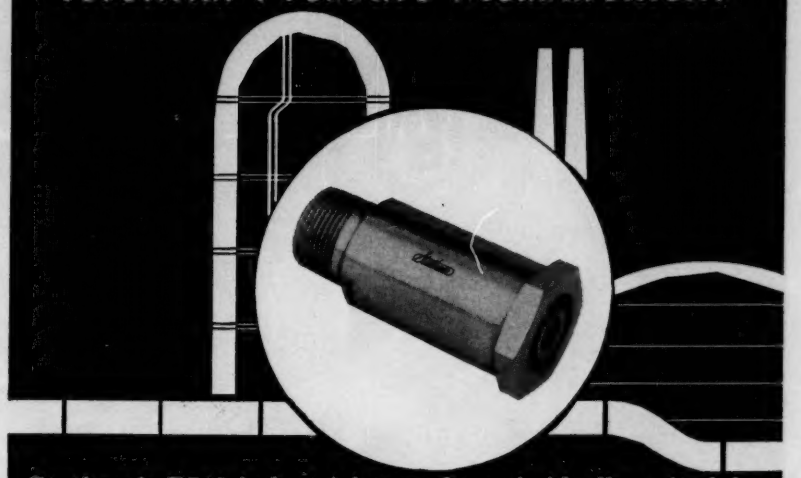
Mr. Merlihan has put his finger on a basic difference between the various types of filled-system thermometers, and an error in our table. Class I (liquid filled), and Class V (mercury filled) are volume-expansion systems. They indicate a change in the *volume* of the filling medium and not pressure. A pressure head between the pickup and final actuating element has no effect. With vapor-pressure thermometers, however, a static head of liquid between pickup and final actuating element does affect the reading. An error will result if the bulb and actuating element are at different elevations and liquid is in the capillary. Classes IIB and IID always have liquid in the capillary; class IIC may have. Note: Class III (gas-filled) also is pressure-actuated, but never has liquid in the system.

Editor, I&CS:

May 5 marks Alan-B.-Shepard-Jr. first-American-spacemen-in-orbit day and we rather imagine that it will have its electric effect in more ways than one on the coming contents of magazines like yours. Without all those automatic and semi-automatic instruments and control systems, how could he have done it?

Arthur F. Joy
Raytheon Company
Lexington 73, Mass.

NEW CONCEPT
In Process Control Instrumentation for Gage, Absolute and Differential Pressure Measurement



Statham's P713 industrial transducer is ideally suited for process flow applications in the petro-chemical, food and utility industries. This rugged and dependable instrument is electrically calibrated at the control room, eliminating field adjustments and down-time associated with conventional instrumentation. The Statham P713 features a unique "Dimensionless" strain gage principle, a major advance in gage design, which gives outstanding performance in temperature stability and long term zero drift. For the first time, the P713 offers industry a low cost, high performance electrical transmitter for control, data logging and computer systems.

CHECK THESE OUTSTANDING FEATURES OF THE P713
- Outstanding performance in temperature stability and long term zero drift.
- Accommodates standard outdoor conduit fittings.
- Tamper-proof, requires no field adjustments.
- Water-tight sealed case.
- Infinite resolution.
- Insensitivity to vibration and shock.
- Compact size.
- Ultimate in ruggedness, simplicity and reliability.

"Dimensionless" principle is described in a free 28-page booklet, "Transducers for Industrial Instrumentation." Write for your copy now.

Statham STRAIN GAGE DIVISION

Statham Instruments, Inc., 12401 W. Olympic Blvd.
Los Angeles 64, Calif. GRanite 8-0361 TWX: West Los Angeles CAL 6502

CIRCLE 10 ON READER-SERVICE CARD

← CIRCLE 71 ON READER-SERVICE CARD

HERE'S THE MOST ADVANCED TEMPERATURE INDICATING CONTROLLER AVAILABLE!

NEW SENSITROL PYROMETER COMBINES

- **Daystrom Creative Engineering**
- **Weston Accuracy and Reliability**

The Daystrom Sensitrol Pyrometer is now available for your *most critical* temperature control applications. This new instrument has an accuracy of ±0.5%, full scale, and a sensitivity of ±0.1%, thanks to a dependable Weston galvanometer sensing element. A non-contact photocell actuates the control . . . completely eliminating drag on the galvanometer.

Here are a few of the many other features offered by Model 8800 Sensitrol Pyrometer: Solid state throughout. Plug-in modular construction for simplicity of maintenance . . . no soldering required. Only 10 3/16" x 7½", the unit can be flush or panel mounted. It has a long 6-inch scale, range of 0-400 to 0-4,000 F, with set points adjustable over entire range. Signal lights at each end of the scale make it easy to read control position from a distance. Two modes—ON-OFF or three position.

Write today for complete technical data or applications assistance on the new Sensitrol Pyrometer—a product of unexcelled Daystrom experience and traditional Weston accuracy! Daystrom, Incorporated, Weston Instruments Division, 229 Manchester Road, Poughkeepsie, N. Y.

International Sales Division, 100 Empire St., Newark 12, N. J. In Canada: Daystrom Ltd., 1480 Dundas Highway East, Cooksville, Ontario.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 11 ON READER-SERVICE CARD

ICS NEWS

Permits High-Speed Contact Printing

SAN DIEGO, CALIF.—Tiny light pipes, smaller than a human hair in diameter, have made possible dramatic advances in the construction and performance of cathode ray tubes. A cathode ray tube, utilizing the Charactron® Shaped Beam Tube method of character generation, to-

gether with a full page-width fiber optics faceplate 8½" long and a ½" wide, is the result of two years of intensive research by Information Technology Division of General Dynamics.

The fiber optics strip in the face of the Charactron® Shaped Beam Tube greatly improves the optical system for line-at-a-time printing of vital computer readout data. The tubes are destined to become an integral part of the division's S-C series of computer readout, printing and recording equipment.

The fiber optics techniques will (1) eliminate conventional lens system and (2) allow direct contact printing by incorporating the character-generating cathode-ray tube in the recorder housing. This permits operation at equivalent output brightness with lower deflection power and accelerating voltages, in turn reducing system complexity, weight and size.

CIRCLE 205 ON READER-SERVICE CARD

MINNEAPOLIS-HONEYWELL'S Special Systems Division has sold four digital computers to Monsanto Chemical Company for on-line control computation in its major plant for ethylene and ethylene co-products currently under construction at Chocolate Bayou, Texas.

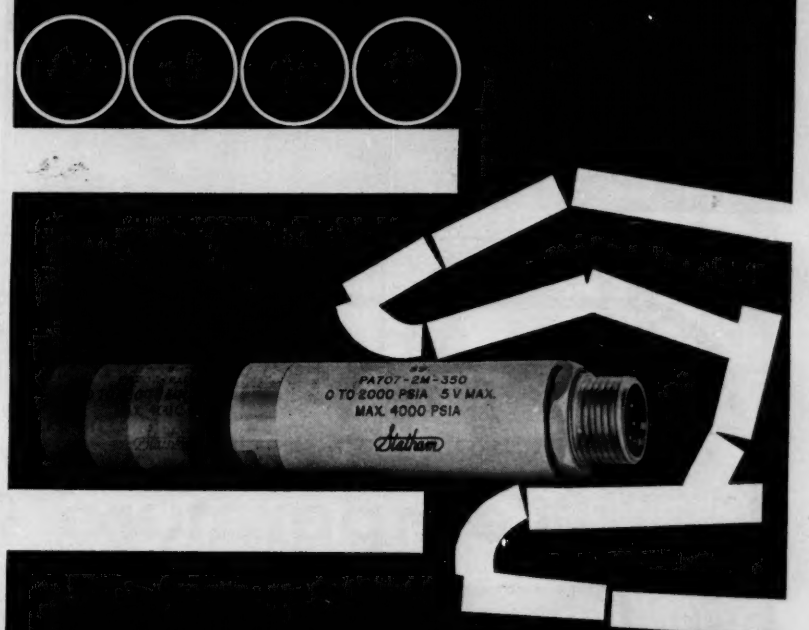
CIRCLE 206 ON READER-SERVICE CARD

CONTROL CORPORATION, Subsidiary of Control Data Corp., has received a contract for approximately $150,000 for the initial part of the new 8000-Series Solid State Control System to regulate the flow of natural gas in the pipelines of Texas Eastern Transmission Corporation.

(*Continued on page* 1569)

CIRCLE 12 ON READER-SERVICE CARD →

NOW AVAILABLE FROM STOCK!!!



Statham's Multi-purpose P707 Pressure Transducers

Statham's Model P707 series of rugged, general purpose pressure transducers are now available for immediate delivery! The compact, lightweight P707 has been designed to withstand the stringent environmental conditions encountered in high performance aircraft, space probes, and ballistic missiles.

This Zero-length dimensionless pressure transducer features a wide variety of ranges, low sensitivity to acceleration, and excellent thermal performance without sacrifice in frequency response or in non-linearity and hysteresis characteristics. Available for measurement of absolute and gage pressures from 0-5 psi through 0-5,000 psi.

For complete data on the P707 contact the Statham sales office in your area or write to:

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Straight-Line Temperature Control

with Thermo Electronic Proportional Controller

Used with a conventional Self-Balancing Recorder or Indicator, and a transmitting slide-wire, the Thermo Electronic Proportional Controller functions as a time-proportioning device. It combines high performance and operating simplicity at a lower initial investment. Outstanding Features include . . .

Minimum Overshoot – Sensitive and continuous adjustment of control action as the set-point is approached prevents overshoot. Your processes are rapidly brought to set-point and closely maintained.

Minimum Cycling – Cycling is almost imperceptible, and since proportional action is limited to the low side of the set-point, "Hunting" or wild oscillation is eliminated. Recordings of your processes will appear to show "Straight Line Action."

Simplified Operation – Only two, non-critical adjustments are necessary – the proportional band and the load range. The conventional, highly critical, reset function adjustment has been eliminated. 100% proportional band adjustment provides widest control action.

Wide Application – Any process using on-off or high-low temperature control is accurately regulated with this Proportional Controller. These include electric furnaces, band or zone heaters on plastic extruders, solenoid valves, and others. The instrument can directly actuate control devices, or can be used to actuate a load relay.

High Accuracy – Electrical accuracy is ¼ of 1% of controller span, as related to accuracy of primary instrument.

The Thermo Electronic Proportional Controller is a unique concept in design for instruments of this type.

WRITE TODAY FOR YOUR 4-PAGE BULLETIN 53-12.

Thermo Electric

Temperature Measuring Systems and Components

20 YEARS

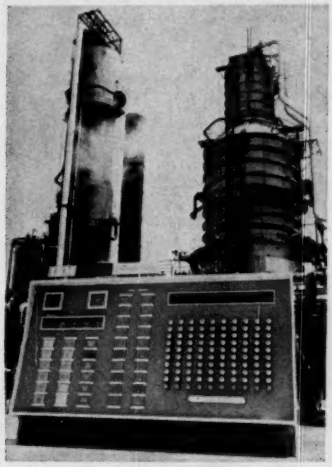
THERMO ELECTRIC Co., Inc., Saddle Brook, New Jersey
In Canada: THERMO ELECTRIC (Canada) LTD., Brampton, Ont.

CIRCLE 9 ON READER-SERVICE CARD

Process Control System for Distillation Unit

CHICAGO, ILL.—American Oil Company has installed the first closed-loop process control system developed by International Business Machines Corporation. The system will control American's 140,000-barrel-a-day crude-oil distillation unit, the world's largest, at its Whiting, Ind., refinery.

The giant crude unit for the last year has been connected by a Process Monitoring System to an IBM 704



computer in the American Oil Technical Computing Center more than a mile away. With the new system, the crude unit will be under continuous computer control instead of periodic guidance with the 704 system.

The control system is built around an IBM 1620 solid-state digital computer coupled to a large random access memory storage, and an input/output system for linking the crude unit instruments and the computer. The crude-still operators are supplied with an operator's console (illustrated) for making inquiries of the computer and for inserting information into the computer such as product specification changes or the latest laboratory results. This is done by manipulating sense switches and entering information into a keyboard.

A typewriter on the console, and a logging typewriter, supply operators with needed information from the computer. The system is capable of scanning 250 instruments and resetting up to 24 control instruments in closed-loop control.

CIRCLE 207 ON READER-SERVICE CARD

(*Continued on page* 1571)

GAIN MORE GAIN
with Statham's new SA9-0 DC to DC Signal Amplifier

Here's a major advance in DC signal amplifier design that gives you the HIGHEST GAIN available today—combined with a wider temperature range, a smaller sized package, and unequalled stability! The new versatile SA9-0 provides complete utilization of low-level DC signals from thermocouples, thermal sensing to bridges and DC excited transducers, etc. It gives you the utmost in dependability under extreme environmental conditions. Modular construction makes the compact transistorized SA9-0 ideal for airborne applications requiring multiple channel installation in limited space. Write for complete technical data!

GAIN:	Continuously variable from 50 to 500. (Special models up to 1000)
TEMPERATURE RANGE	
OPERATING:	−65° F. to +165° F.
NON-OPERATING:	−65° F. to +225° F.
THERMAL COEFFICIENT OF SENSITIVITY:	0.02% / °F.
THERMAL ZERO SHIFT:	0.01% / °F. of full scale output.
OUTPUT:	0 to 5 V DC
INPUT REQUIREMENTS:	0 to 5 mv DC.
POWER REQUIREMENTS:	30 ma at 28 V DC ± 10%.
WEIGHT:	8 oz. (approx.)
SIZE:	less than 8 cu. in.

Statham ELECTRONICS ED DIVISION

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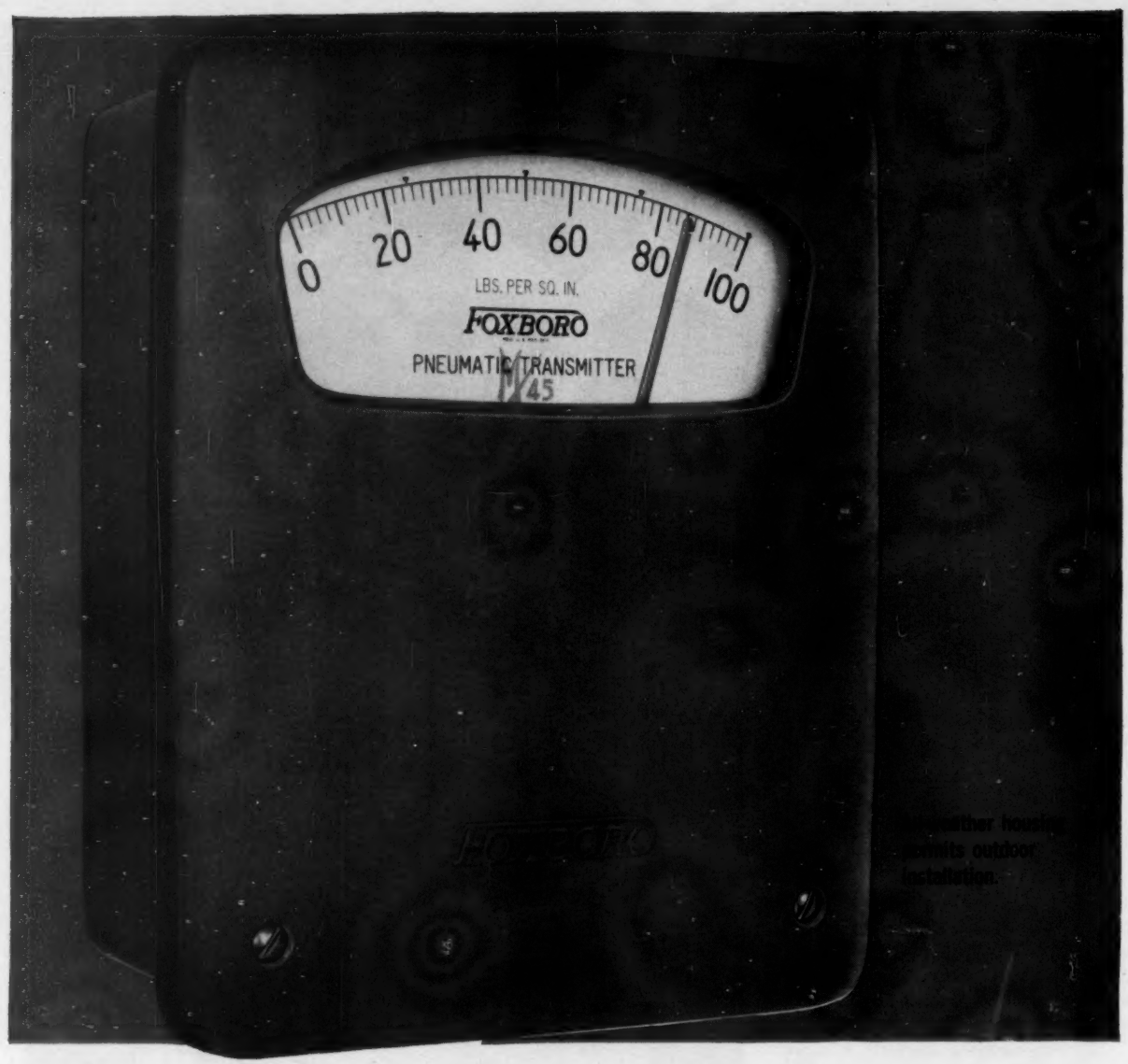
CIRCLE 14 ON READER-SERVICE CARD



You can use this new Foxboro pneumatic transmitter on six different process measurements

pressure – temperature – liquid level – differential pressure – dew point – flow... all six with guaranteed accuracy of ±½ of 1%

Think of it . . . a universal pneumatic transmitter with matched elements for six different process variables. That's the new Foxboro M/45 pneumatic indicating transmitter.

And with the M/45 you get: *universal* high accuracy-guaranteed at ±½ of 1%; *universal* ambient temperature stability — less than ½ of 1% in 50°F temperature change; *universal* calibration and simplicity of servicing. A remarkable combination of versatility and uniformity in a single instrument.

The new Foxboro M/45 indicating transmitter can extend the benefits of standardization throughout your whole plant operation. Ask your Foxboro field engineer to tell you about it. Or write for Bulletin 13-30. The Foxboro Company, 469 Norfolk St., Foxboro, Mass.

FOXBORO

REG. U. S. PAT. OFF.

CIRCLE 15 ON READER-SERVICE CARD

National Conference on Weights and Measures

WASHINGTON, D. C.—Nearly 400 delegates recently attended the 46th National Conference on Weights and Measures in Washington, D. C., with weights and measures officials representing 35 States, the District of Columbia, and the Commonwealth of Puerto Rico. Also represented were the Institute of Weights and Measures Administration of Great Britain, and the Standards Division of the Department of Trade and Commerce of Canada.

The Conference, which is sponsored by the National Bureau of Standards and brings together weights and measures officials, as well as representatives of business, heard Secretary of Commerce *Luther H. Hodges* at the opening session, and NBS Director *A .V. Astin*, President of the National Conference, who reviewed recent technical achievements of the Bureau in the field of measurement, giving particular attention to accomplishments of significance to the weights and measures field. *Dr. Astin* was reelected for the coming year.

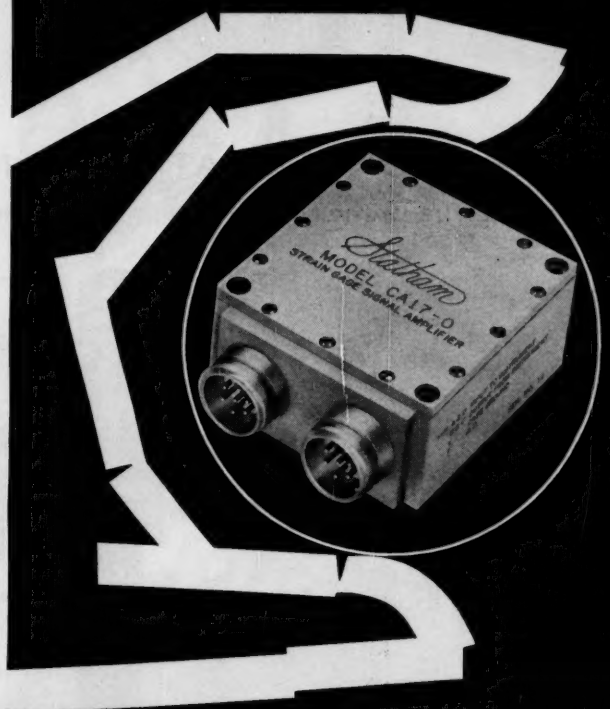
U.S. Automatic Control Team Tours Japan

During the month of May a group of automatic control engineers from the U.S. visited Japan at the invitation of the Japanese National Committee of Automatic Control. *Dr. Rufus Oldenburger*, Professor of Mechanical Engineering and Director of the Automatic Control Center, Purdue University, team chairman has written a report on "Automatic Control in Japan;" *Dr. G. H. Fett*, Professor of Electrical Engineering, University of Illinois, has reported on "University Instruction and Research in Automatic Controls;" *Dr. J. E. Gibson*, Professor of Electrical Engineering, Director of the Information and Control Systems Laboratory, Purdue University, team reporter, has given his attention to "Research in Automatic Control in Japanese Universities;" *Dr. O. J. Smith*, Professor of Electrical Engi-

(*Continued on page* 1573)

Only 4¼ oz. . . . 4 cu. in.

transistorized signal amplifier



DESIGN FEATURE:

Drastically reduced in size, the CA17 carrier amplifier provides for total utilization of low-level signals . . . proves itself more reliable in adverse environments than larger and heavier amplifiers . . . assures the precision required in aircraft and space vehicles. The CA17 may be used with any resistance strain gage transducer. *Excitation:* 28V d.c. ± 5% @ 30ma, including built-in transducer power supply. *Output:* 0-5 Volts d.c.

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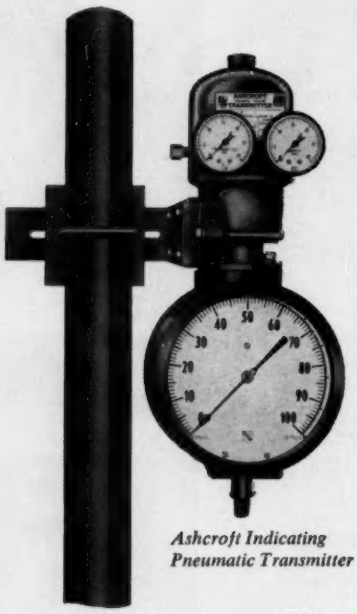
CIRCLE 16 ON READER-SERVICE CARD

signal action

ASHCROFT PNEUMATIC TRANSMITTERS give you a true primary and transmitted signal for indication or control



Ashcroft Indicating Pneumatic Transmitter

Now—detect with precision accuracy the slightest change in primary pressure or temperature. Transmit this signal quickly to your indicators or controllers. Ashcroft Pneumatic Transmitters do the job at lowest initial and operating costs.

Full-range, solid-front indicating and totally accessible nonindicating transmitters need no costly high-pressure lines, yet permit complete monitoring of processes in remote areas. For safety's sake, you get full indication even if the air is shut off.

Narrow-span Ashcroft Transmitters are expressly designed with highest sensitivity and repeatability for the most accurate primary signal feed to controllers. You get better control and purer, lower-cost final products.

Only in Ashcroft Pneumatic Transmitters can you get the wide choice of Ashcroft Duragauge Bourdon tubes or American mercury or gas-actuated sensing systems. You also get a time-proven, obstructionproof, force-balance, non-bleed replay for economical, maintenance-free 3-15 psi or 3-27 psi signal transmission. Both indicating and nonindicating *suppressed* types available.

Write for factful Bulletins 360 and 361 or ask your nearby Ashcroft Distributor to help you select the right transmitters and receiver gauges.

MANNING MAXWELL & MOORE INC. TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

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Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

CIRCLE 17 ON READER-SERVICE CARD

neering, University of California, has reported on "Analog Computers in Japan;" *Dr. W. S. Tandler,* Research Engineer, Arthur D. Little Inc., has given his "Impression of Automation of Mechanical Industries in Japan;" *H. Ziebolz,* Assistant to the Vice President of Engineering, General Precision Equipment Corp., has summarized "Remarks Regarding Automation in the Heavy Industry;" *Dr. S. W. Herwald,* Vice President in charge of Engineering, Westinghouse Electric Corporation has written "Some Brief Comments on the Radio-Television Industry in Japan;" *Dr. J. O. Hougen,* Technologist, Systems Section Monsanto Chemical Company, has written "Log of U.S. Automatic Control Team Tours Japan;" and *A. F. Sperry,* Chairman of the Board, retired, Information Systems, Inc., and Engineering Consultant has focused his interest on "Digital Computers and Data Processing in Japan."

Copies of these reports may be obtained from Prof. R. Oldenburger, Purdue University, Lafayette, Indiana.

International Measurement Conference

BUDAPEST, HUNGARY—Close to 400 scientists and technical experts from 25 countries attended the recent IMEKO 1961 conference in Budapest with an additional 250 Hungarian participants. There were 18 participants from the United States, as listed below; 135 papers from 22 countries were read and discussed in public.

Prof. A. N. Letov at IMEKO banquet

On behalf of IFAC, *Prof A. N. Letov* (Institute for Automation and Telemechanics, Moscow) greeted those present at the IMEKO banquet. The others in the picture are Executive Secretary of IMEKO, *Dr.*

(*Continued on page* 1574)

NOW, accurately measure high or low pressures continuously at + 600°F

Statham's new P732 series of high temperature gage and differential transducers accurately measure pressures over a wide variety of ranges and under extreme environmental conditions.

The small and light weight P732 pressure transducers—of rugged stainless steel construction—are temperature compensated for continuous operation to + 600° F. Pressure ranges on the gage and uni-directional differential models are from 0-2 psi through 0-5,000 psi. The bi-directional differential model operates in ranges from ± 1 psi through ± 100 psi.

For your high temperature pressure measurements—for aero-space, nuclear or industrial applications—specify the superior performance of Statham's versatile P732!

COMPARE STATHAM'S COMBINATION OF SUPERIOR PERFORMANCE CHARACTERISTICS

1. Better temperature stability through Statham's new, exclusive zero-length/dimensionless unbonded strain gage.
2. Higher overload characteristics for safer and longer operation.
3. Lower sensitivity to static and vibratory acceleration for more accurate pressure measurements.
4. Combined non-linearity and hysteresis of less than ± 0.75% in *both* high and low pressure ranges.
5. Ambient temperature limits from − 320° F. to + 650° F.

For complete data write today to:

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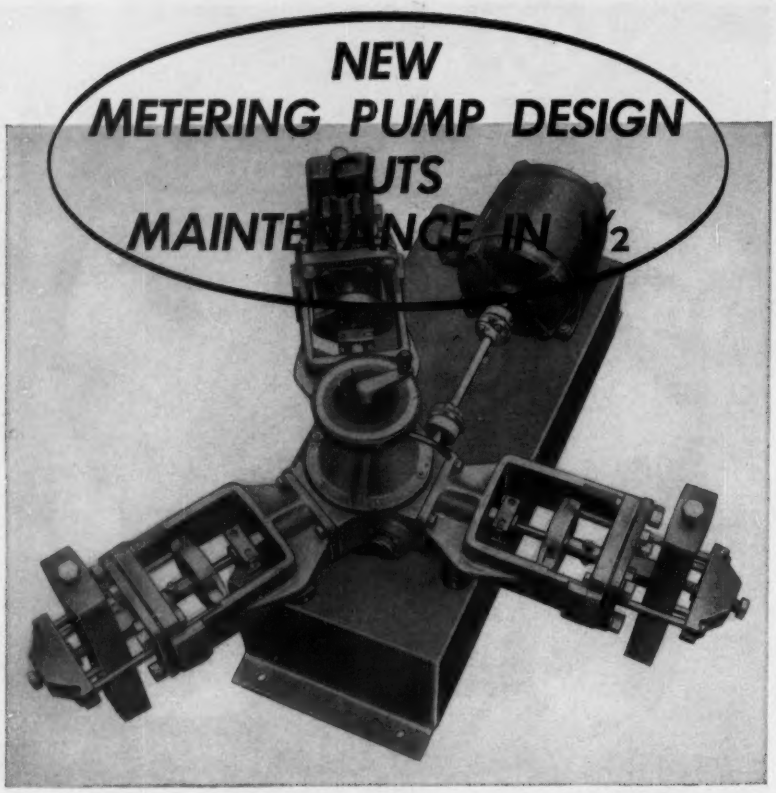
CIRCLE 18 ON READER-SERVICE CARD



Wallace & Tiernan's new Heavy Duty Metering Pump is designed to take all pumping stresses in the gear case, not in the base. This pump stays in perfect alignment, holds accuracy for life. The tendency to twist components loose from the base is gone — and with it half the maintenance headaches.

Maintenance "musts" that remain are simplified by design. The entire stuffing box is removable to speed plunger repacking. Suction and discharge valves are dismantled for cleaning without disconnecting piping. The entire liquid end is changed by removing just four bolts and a clamp.

Because its design eliminates cantilever loads, the W&T Metering Pump does not require a massive base. A U-type steel base supports the pump, raises it to leave room for cleaning and piping underneath.

The unique drive unit is completely enclosed. Corrosion and foreign matter are sealed out . . . preventive maintenance built in.

Job-proportioned W&T Metering Pumps are available in simplex, duplex, and triplex models. Simplex capacities range from 0.65 to 7.8 gph up to 4000 psi to 32 to 390 gph up to 165 psi.

For other helpful features, write Dept. L-12.48

WALLACE & TIERNAN INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

CIRCLE 19 ON READER-SERVICE CARD

Gyorgy, and *H. E. Burke*, leader of the USA delegation.

Americans participating included *Verne R. Boulton*, Assistant Manager, Test Division, Secramento Plants, Aerojet General Corp., *Harry E. Burke, Jr.*, Vice President and General Manager, Consolidated Systems, Corp.; *Dr. Leland Cole*, Vice President, Beckman Instruments; *Robert Gorton*, Development Engineer, Pratt and Whitney Aircraft; *Andrew D. Hasley*, Component Development Engineer, Bell Telephone Labs; *Dr. Wilbur Kaye*, Scientific and Process Instruments Div., Beckman Instruments; *Harvey W. Lance*, Physicist, U. S. National Bureau of Standards, Chief, Electronic Calibration Center; *Dr. Robert G. Langford*, Director of Engineering, Weston Instruments; *Dr. John H. Laub*, Chief, Guidance and Control Research, Jet Propulsion Laboratory; *Dr. Douglas F. Muster*, Mechanical Engineer, General Electric Co., General Engineering Lab.; *Dr. Thomas A. Perls*, Staff Scientist, Physics, Lockheed Aircraft Corp., Missiles Systems Division; *Dr. J. M. Pettit*, Prof. of Electrical Engineering and Dean of School of Engineering, Stanford University; *Dr. William S. Rodney*, Research Administrator, Office of Aerospace Research; *Dr. Beno Sternlicht*, Consulting Engineer Hydrodynamics, General Electric Co.; *John K. Stotz*, Grumman Aircraft Engineering Co., Instrumentation Dept.; *Bertram Stiller*, Physicist, U. S. Naval Research Laboratory; *George Toumanoff*, Airborne Instrument Laboratory.

INFORMATION SYSTEMS has sold an ISI 609 Information and Computer System to the Tidewater-Collier Naphthalene Plant, Delaware City. The "first such system to be installed in a naphthalene plant in this country," it will scan 300 temperatures, pressures, flows, and fluid levels with an expansion capability to 500 points.

TRW COMPUTERS COMPANY, a division of Thompson Ramo Wooldridge Inc., has sold a RW-300 computer control system to Allied Chemical Corporation for its Ironton, Ohio, ammonia plant. This plant, operated by Allied's Nitrogen Division, is the "largest ammonia plant for which the computer control has been announced."

INDUSTRY NEWS

BAILEY METER COMPANY announces the appointment of five men to direct the company's engineering departments: *A. J. Hornfeck* (Director of Research), *J. E. McEvoy* (Manager, Product Engineering Department), *R. E. Clark*, (Manager, Equipment Engineering Department), *J. K. Loeser* (Manager, project Engineering Department), *J. V. Werme*, (Manager, Electrical Engineering Department).

A. J. Hornfeck

GENERAL PRECISION, INC., the principal operating subsidiary of General Precision Equipment Corporation, announces the creation of the new position of Vice President and Chief Scientist, and named *Dr. Raymond L. Garman* to fill the post. General Precision also announces the appointment of *David Balber* to the newly created position of Director of Advanced Product Development for General Precision, Inc. He will be responsible for the direction and coordination of all new product development activities for the company.

Dr. R. L. Garman

David Balber

SHEPHERD ELECTRONIC INDUSTRIES has completed moving its offices and plant operations into a new 25,000-sq-ft building on Terminal Drive at the Plainview Industrial Park, Plainview, L.I., N. Y.

MEASURE ABSOLUTE PRESSURES with SPEED and PRECISION

With Wallace & Tiernan Aneroid Dial Indicators you get precision and fast response in all types of absolute pressure work.

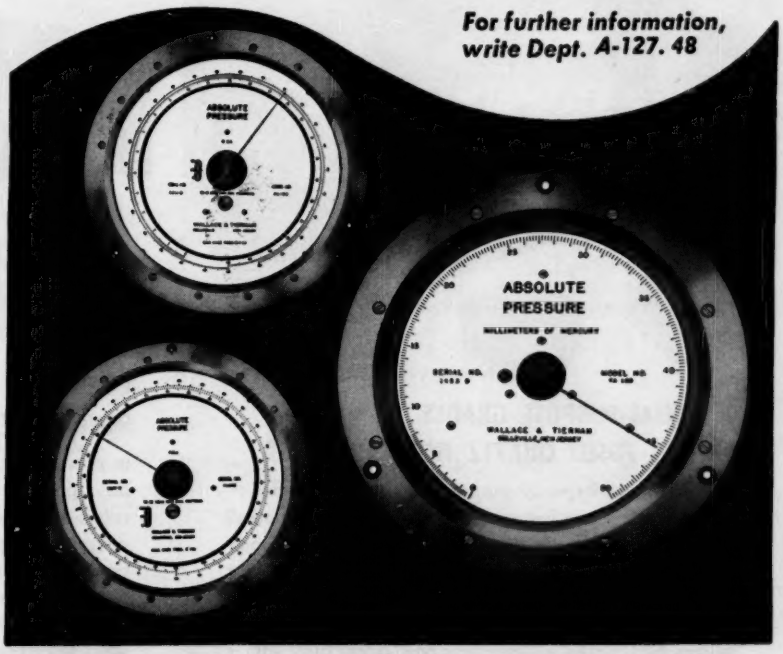
W&T Precision Indicators have many uses in research and development engineering. One is ideal for calibrating pressure transducers; another, for checking the calibration of flight instruments and ground support equipment. These instruments also keep constant check on continuous production-line work.

A W&T Absolute Pressure Gauge on the job means:

- ★ Accuracy 0.1% to 0.33%
- ★ Sensitivity 0.01% to 0.2%
- ★ Range 0.1-20 mm Hg to 0-500 p.s.i.a
- ★ No corrections
- ★ Light weight, small size

The accuracy of W&T Absolute Pressure Indicators approaches that of liquid columns... higher sensitivity assures faster response... large dial gives quick reading.

For further information, write Dept. A-127. 48



WALLACE & TIERNAN INCORPORATED

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CIRCLE 20 ON READER-SERVICE CARD

PORTABLE INSTRUMENT MEASURES OXYGEN AND MOISTURE IN HYDROGEN AND INERT GASES

The Engelhard Portable Atmosphere Analyzer is an ideal instrument for detection and measurement of harmful impurities usually found in gases used in the manufacture of semiconductors and other electronic devices. Analyzes and records atmospheres in furnaces, glove boxes and other critical areas. Oxygen analysis down to less than 1 PPM, moisture analysis down to 1 PPM. Write for literature.

INDUSTRIAL EQUIPMENT DIVISION
GAS EQUIPMENT SECTION
113 ASTOR STREET • NEWARK, N. J.

FOR DETECTION AND MEASUREMENT OF OXYGEN OR HYDROGEN IMPURITIES IN OTHER GASES

Super-sensitive Deoxo Indicator . . . continuously measures oxygen or hydrogen present as impurities in other gases—from 2 to 200 parts per million oxygen and 4 to 400 parts per million hydrogen. Dual range permits measurement up to .25% oxygen or .50% hydrogen.

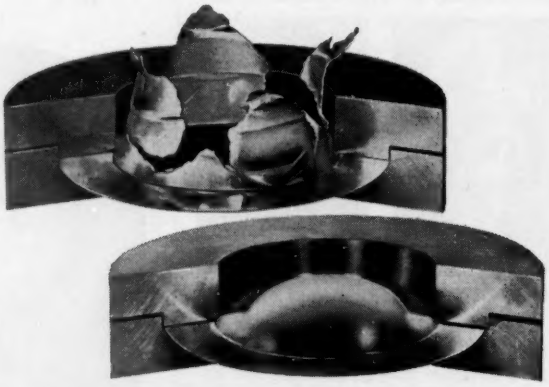
INDUSTRIAL EQUIPMENT DIVISION
GAS EQUIPMENT SECTION
113 ASTOR STREET • NEWARK, N. J.

9 SPECIAL-PURPOSE GRADES OPTICAL FUSED QUARTZ NOW AVAILABLE

Amersil makes 9 special-purpose high quality grades of fused quartz. Each has special characteristics. Included in these 9 grades are some to be used for Ultra-violet transmission and other for Infra-Red. • Used in light sources for radiation, components for optical systems, ultrasonic delay lines and as substitute for rock crystal prisms and lenses in spectographic apparatus, etc. • In addition, lenses and prisms can be supplied in small dimensions.

AMERSIL QUARTZ DIVISION
685 RAMSEY AVENUE • HILLSIDE, N. J.

FOR ATMOSPHERE ANALYZER CIRCLE 21 ON READER-SERVICE CARD
FOR FUSED QUARTZ CIRCLE 22 ON READER-SERVICE CARD

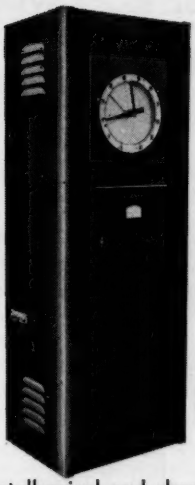


CORROSION-RESISTANT RUPTURE DISCS RELIEVE PRESSURE AUTOMATICALLY

In pressurized apparatus subject to corrosion, dependable precious metal rupture discs provide speediest, safest, most accurate relief from excess pressures. Made of gold, silver or platinum to resist corrosive effects of liquids and gases under conditions that would render many base metal materials useless. Complete line of rupture discs available—guaranteed to burst at ±5% of specified pressure. Economical to use—cost lowered by recovery of precious metal in spent disc. Write for literature.

BAKER PLATINUM DIVISION
113 ASTOR STREET • NEWARK, N. J.

FOR DEOXO INDICATOR CIRCLE 23 ON READER-SERVICE CARD
FOR RUPTURE DISCS CIRCLE 24 ON READER-SERVICE CARD



FOR DETECTION AND MEASUREMENT OF OXYGEN IMPURITIES IN OTHER GASES

In metallurgical and chemical processes requiring an oxygen-free atmosphere, the Minoxo Indicator provides a means of insuring that failure of purification or ingress of atmospheric oxygen through an unsuspected leak does not cause costly spoilage. The Minoxo Indicator . . . measures traces of molecular oxygen in other gases—from 0 to 10 parts per million, and from 0 to 100 PPM. High sensitivity and rapid speed of response enable it to be used for laboratory investigation and production quality control.

INDUSTRIAL EQUIPMENT DIVISION
GAS EQUIPMENT SECTION
113 ASTOR STREET • NEWARK, N. J.

HERMACH-ENGELHARD MULTI-RANGE TRANSFER VOLT-AMMETERS FOR UNMATCHED ACCURACY

Meets exacting calibration requirements for accuracy without use of correction factors over wide range of currents and voltages. Functional design employs null principle . . . provides simple operation. Hermach-Engelhard Transfer Volt-Ammeter achieves 0.05% accuracy through frequency range d-c to 50,000 cps, eliminating complete battery of measuring devices otherwise needed. • Several models available for efficient adaptability to various conditions. Write for details.

INDUSTRIAL EQUIPMENT DIVISION
INSTRUMENTS AND SYSTEMS SECTION
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PRECIOUS METAL CONTACTS FOR HIGH-RELIABILITY

Precious metal contacts in pure or alloyed forms of silver, platinum, palladium and gold provide unmatched resistance to atmospheric corrosion, deformation, arc erosion, binding and metal transfer. Baker high-reliability precious metal contacts are supplied as wire, rod, sheet and in a complete line of fabricated forms. Facilities are also available for manufacture to your specifications.

BAKER CONTACT DIVISION
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FOR MINOXO INDICATOR CIRCLE 25 ON READER-SERVICE CARD
FOR PRECIOUS METAL CONTACTS CIRCLE 26 ON READER-SERVICE CARD

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☐ Minoxo Indicator ☐ Precious Metal Contacts

☐ Super-Sensitive Deoxo Indicator ☐ Rupture Discs

☐ Portable Atmosphere Analyzer ☐ Fused Quartz

☐ Hermach-Engelhard Volt-Ammeters

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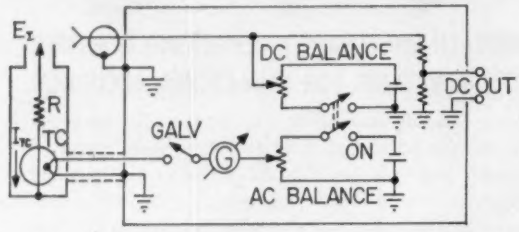
FOR VOLT-AMMETERS CIRCLE 27 ON READER-SERVICE CARD

High Frequency Voltage Standard

The Ballantine Model 393 High Frequency Transfer Voltmeter has been designed to measure ac voltages from 1 V to 50 V at frequencies from 25 cps to 30 Mc with ac-



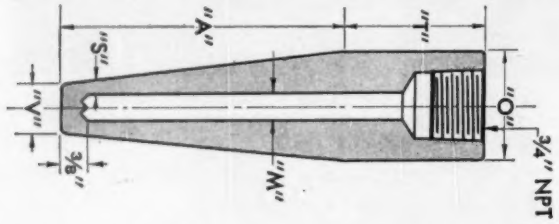
curacies required in standards laboratories. It is a transfer device whereby an ac voltage is determined by equating its heating effect to that of an accurately measurable dc voltage.

The HF Transfer Voltmeter consists of a Transfer Unit and a set of five probes each capable of use over a 2 to 1 range of ac voltages. The Transfer Unit houses a sensitive galvanometer, batteries, controls, and accurate dividers. Each probe contains a stable measuring resistor, and a thermocouple . . . (*From new 4-page bulletin, Ballantine Laboratories, Inc., Boonton, N. J.*)

FOR THIS LITERATURE CIRCLE 208 ON READER-SERVICE CARD

Thermowells for Thermocouples

Metal protecting wells for the primary or detecting elements of all types of temperature indicating, recording, and controlling instruments . . . listed in this catalog are

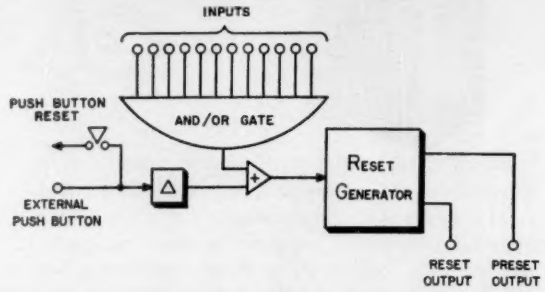


representative of the types and basic styles in popular usage for protection of thermocouple elements throughout the industry . . . Trinity "Weld-in" wells are used where high pressure and temperature conditions preclude the use of conventional thermowell connections . . . The utilization of constantly increasing pressures, elevated temperatures, and highly corrosive solutions has made necessary the use of many alloys heretofore not available for thermowells. Trinity offers the most complete variety of alloys to meet every thermowell requirement: Standard Materials are 304SS, 316SS, 347SS, ASTM A182-F11 (1¼% Chrome, ½% Moly), and ASTM A182-F22 (2¼% Chrome, 1% Moly) . . . (*From new 8-page Bulletin TT-301, Trinity Equipment Corp., Cortland, N. Y.*)

FOR THIS LITERATURE CIRCLE 209 ON READER-SERVICE CARD

Logic Modules

5" x 6" glass epoxy etched-circuit plug-in cards have been designed to provide the ultimate in compact transistorized digital systems functions. Each module is a



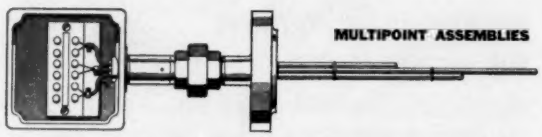
multiple stage unit with the logical functions organized to minimize card to card wiring. Most of the modules include at least 5 logic stages, such as 5 stage shift registers, 5 bit binary counters, 10 inverting amplifiers, etc. . . .

The Model 327 Reset Generator contains a twelve input gate which triggers a high power Reset Generator, capable of resetting a large number of stages. The Model 327A has a twelve input AND gate, while the Model 327B has a twelve input OR gate. All unused inputs may be ignored. A push button mounted on the handle bracket permits manual operation of the reset generator, regardless of the state of the input gate . . . Frequency: 10 KC maximum continuous, 100 KC intermittent; inputs: 327A —1 ma clamp, 327B—1 ma drive—(not directly from flip-flops); outputs: reset output—400 ma drive pulse 5 μs wide . . . (*From new 16-page Catalog "300 Series," Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa.*)

FOR THIS LITERATURE CIRCLE 210 ON READER-SERVICE CARD

Metal-Sheathed Thermocouple Elements

Trinox is a metal-sheathed cable, containing thermocouple wires which are insulated by a hard-packed inert metallic oxide. It is designed to meet the installation re-



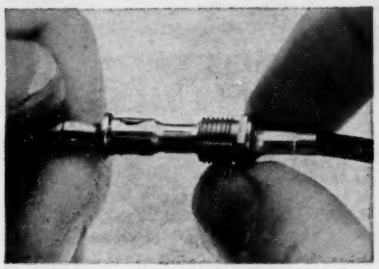
quirements not suited to the thermocouple-element and separate thermowell assembly . . .

Trinox can be used to advantage in the fabrication of multipoint assemblies . . . any number of Trinox elements may be "bundled", with hot junctions at various points in the system . . . (*From new 8-page Bulletin TT-317, Trinity Equipment Corp., Cortland, N. Y.*)

FOR THIS LITERATURE CIRCLE 211 ON READER-SERVICE CARD

(*Continued on page* 1590)

Crimp-type Connectors

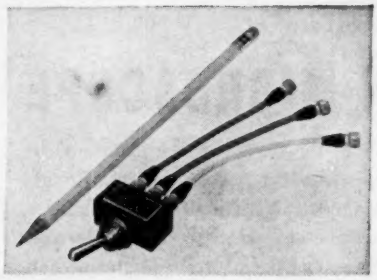


These solderless, coaxial connectors are available in a variety of mounting configurations, including snap-locking versions. Male and female connectors may be mounted interchangeably. Mated length is 1 13/16". Working voltages: 1,000 V. maximum, at sea level; 500 V. maximum, at 60,000 feet. VSWR; less than 1.2 up to 2,000 mc. Life; 5,000 matings, minimum, without electrical deterioration. Tensile strengths of the crimps exceed the breaking strength of the cable. Hard gold plated Beryllium copper and TFE plastic are extensively used to assure optimum reliability.

Microdot, Inc., 220 Pasadena Avenue, South Pasadena, California

CIRCLE 28 ON READER-SERVICE CARD

Coaxial Switch



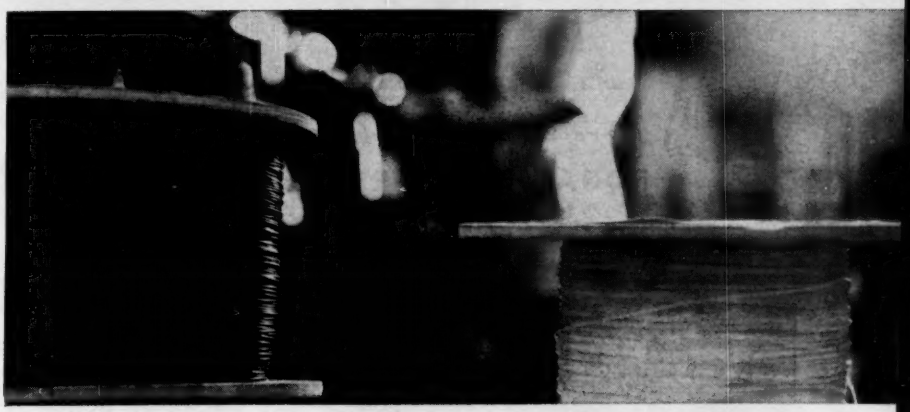
SPDT miniaturized switch features a case volume of ½ cu. in. and weight of 1¼ oz. Design allows direct insertion into miniaturized circuit without cumbersome adapters. Toggle action is positive, rf characteristics are highly efficient. VSWR is less than 1.25 to 2.0 kmc. Insertion loss is 0.8 db at 2.0 kmc. Contact rating is ½ amp at 150 V. resistive. Operating is 50,000 operations, minimum. Special stripline manufacturing technique provides low loss, wide frequency band properties.

Microdot, Inc., 220 Pasadena Avenue, South Pasadena, California

CIRCLE 29 ON READER-SERVICE CARD

For Microminiature Coaxial Cable Circle 30 on Reader Service Card ←

MICROMINIATURE COAXIAL CABLE

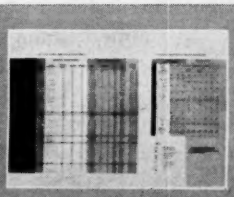


Microdot's Cable Facilities specialize in precise metallic braiding of microminiature coaxial cables. In a new, ultra-modern plant, special advanced techniques of cylindrical weaving are combined with the utilization of highest quality materials and rigid quality control methods, to produce a wide range of miniaturized RF frequency cables... cables designed and produced to yield the same matched impedance as required for larger cables.

"Mini-Noise" cable, a result of Microdot research, is specially processed to minimize self-generated noise—prevents noise interference with low strength signals. These cables also offer high performance in extreme temperature ranges.

Twinax cable produced by Microdot is a shielded, twisted pair of conductors utilizing prime dielectrics for low loss, featuring controlled capacitance and impedance. Shield is added after insulation and conductors are arranged in a balanced to ground configuration.

Triax cable by Microdot offers rf leakage below the level experienced with Double Shielded Coax. Three active conductors permit feedback to cancel a known noise source. Capacitance-cancelling hook-ups are possible for cathode followers.



Use reader service card in this publication, or write today for 4-page folder of performance charts, design characteristics, and specifications on the following cables: Coax 50, 70, 75, 93, 95 ohm. Twinax 125 and 160 ohm. Triax 50 and 93 ohm.

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220 Pasadena Avenue, South Pasadena, Calif.

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New Stock Molded Knobs

AVAILABLE WITH OR WITHOUT SKIRTS

4 Standard Sizes

Meet MIL-P-14 Specs

MODEL RB-1250-SK Illustrated

Molded of thermosetting phenolic or urea materials. Available in 4 standard sizes with nickel plated brass inserts for ¼" or ⅜" diameter shafts. Aluminum decorative inserts or skirts, etched and filled as desired... various anodized finishes, plain or radially spun. Write for new catalog illustrating Rogan's complete line of stock molded knobs.

ROGAN BROTHERS, Inc.

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IGS STOCK REPORT

OVER THE COUNTER

Quotation as of August 15,1961.

	Bid	Asked
Aerovox Corp.	11 1/4	11 3/4
Argus Corp.	43 3/4	44 1/2
Black Sivalls & Bryson Inc.	13	13 1/2
Computer Systems	11 3/4	13 1/2
Eitel McCullough	16 1/8	16 3/4
Electro Instruments	16 3/4	18 1/4
Electronics Associates	29 1/4	30 1/4
Erie Resistor Corporation	12 3/8	13
Fisher Governor Co.	26 1/4	27
Hagan Chemicals & Controls	59	60 3/4
Milgo Electronic Corp.	19 1/2	20 1/2
Industro Transistor	2	2 1/2
Liquidometer Corp.	15	16 1/4
Maxson Electronics	19 1/2	20 1/4
Penn Controls	27 1/2	30
Speer Carbon, Inc.	32 3/4	33 1/2
Sprague Electric	83	84
Taylor Instruments	49 1/4	50 1/4
Telechrome Mfg. Corp.	8	8 3/4
Telecomputing Corp.	6 3/8	6 3/4
Vitro Corp. of Amer.	23 1/4	24
Wallson Associates Inc.	3 3/4	4 1/4

ELECTRONIC CIRCUITRY

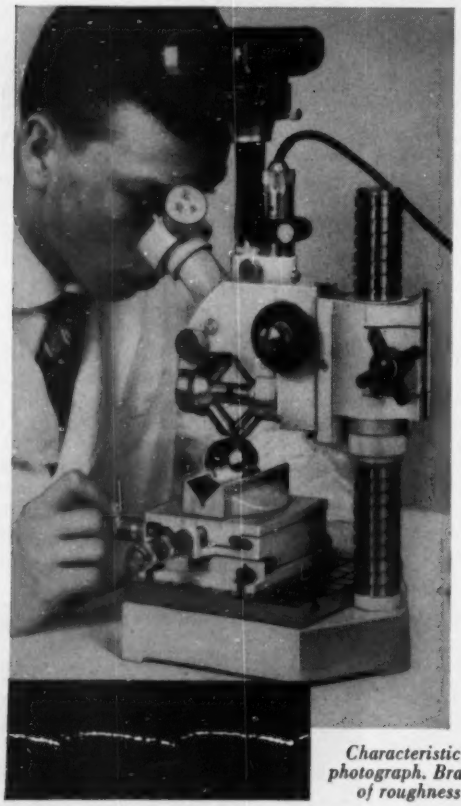
For Instruments and Equipment

by M. H. ARONSON

A complete home-study text and course with 459 multiple-choice test items on basic electronic circuitry. **$2.00**

INSTRUMENTS PUBLISHING CO.

845 Ridge Ave. Pittsburgh 12, Pa.



Characteristic light section photograph. Brass, faced, depth of roughness .0008 inch.

CARL ZEISS

WEST GERMANY

LIGHT SECTION MICROSCOPE

This microscope produces a profile of the surface being examined by the well-known light-section method without physical contact. Roughness depth, as well as the groove distances of machine-finished surfaces, can be measured. Internal surfaces can be examined by making lacquer replicas. For checking long work pieces, a special arched intermediate piece is adaptable and included in the main instrument.

The newly developed revolving nose-piece for the objectives makes it possible to quickly change the magnification (height of profile) between 400x and 200x, and the measuring range of the depths of roughness extends from .000040 to .015 inch.

Photographs for comparison and control purposes can be taken by mounting a 35mm camera on top of the instrument.

In addition to the stage plate of the stand, a mechanical stage and center cradle (for round parts) are available.

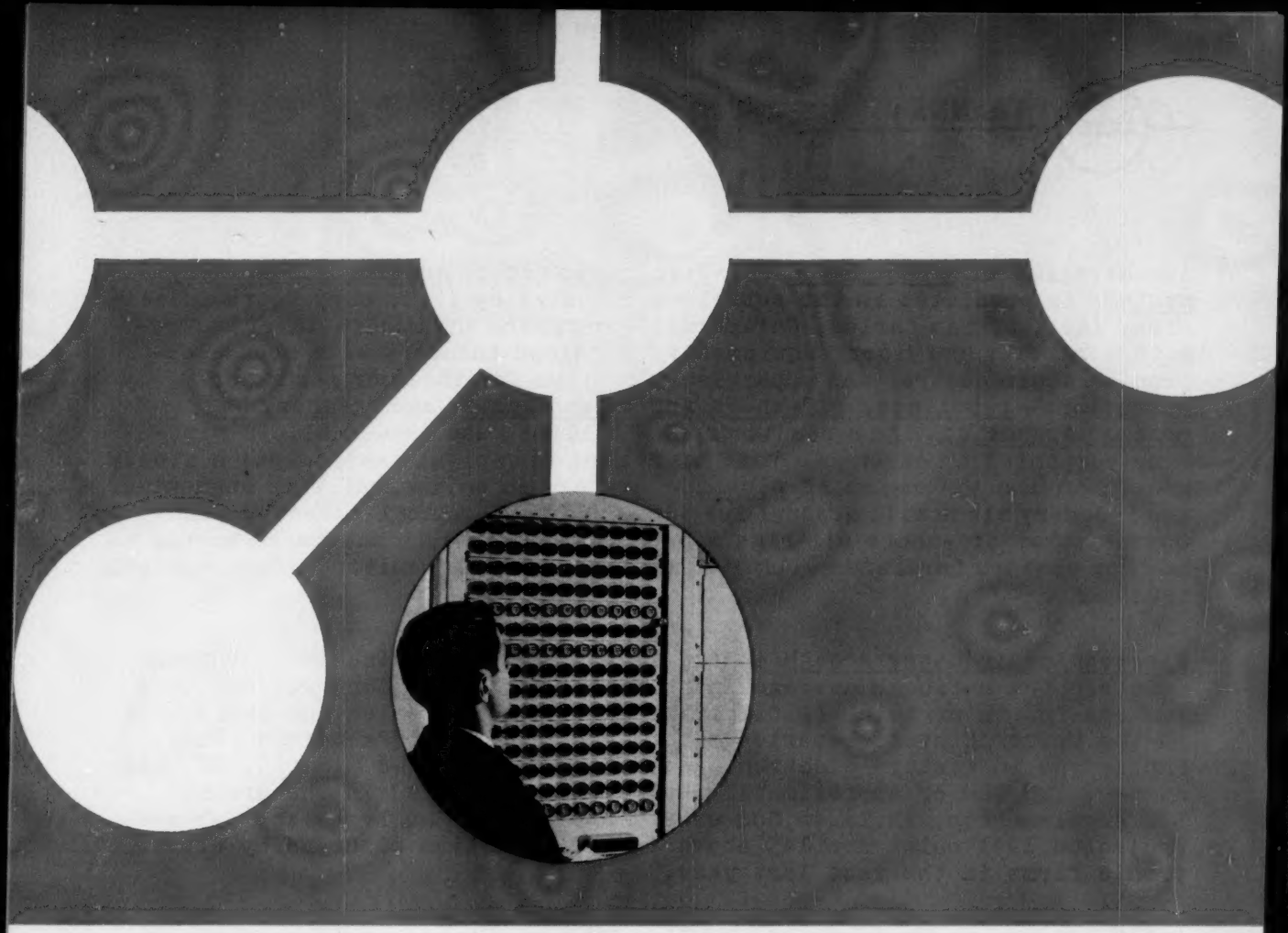
Write for literature

CARL ZEISS, INC.

485 FIFTH AVENUE, NEW YORK 17, N.Y.

COMPLETE SERVICE FACILITIES

CIRCLE 32 ON READER-SERVICE CARD



PROCESS PROTECTOR

Hagan AIM—centralized monitoring of all important variables

Temperatures, pressures, flows, levels, closures, in fact any input that can be represented by DC voltages as low as 10 millivolts full scale can be monitored by the Hagan AIM (Alarm Indicating Monitor) with an accuracy of plus or minus 0.1% full scale.

Fast and reliable, the Hagan AIM is compact—for example, the readout and alarm panel for 200 alarm points will fit into a 19″ x 47¼″ panel area. Combining all alarm functions in one instrument, AIM can be set for high or low alarm points, or both. Seconds after a monitored variable goes out of bounds, AIM energizes the alarm light and sounds a warning horn. The horn can be shut off, but the light stays lit until the condition is corrected. AIM safeguards both equipment and process from the shattering damage that a single runaway variable can produce. Now *one* man can watchdog a complete process line, taking corrective action before damage is done.

AIM is one component of the complete Hagan line of process controls, which include primary elements, transducers, controllers, recorders and final control elements. Designed for use with existing installations or for complete new systems, the Hagan line can save you money in terms of more accurate control with minimum adjustment and maintenance. For information, write or phone HAGAN CHEMICALS AND CONTROLS, INC., Hagan Center, Pittsburgh 30, Pa.

CIRCLE 33 ON READER-SERVICE CARD **HAGAN**

Annual sales of $50 million for electronic remote control supervisory systems is predicted in the petroleum industry by 1965, says Moore Associates, Inc., of San Carlos, California, designers and manufacturers of remote control supervisory equipment. Petroleum industry will need electronic remote control and supervisory systems for three of its major operations—pipelines, off-shore and leased wells, and refinery and process operations. As a result of the Phillips Case (which allows pipeline companies a reasonable rate of return on capital investment) a steady growth in the extension of pipeline systems is envisaged. This segment of the industry alone will account for $35 million in annual sales by 1965. Operation of off-shore oil rigs and the numerous wells scattered across so much of western farmlands will also require central monitoring and control equipment.

Electronics industry growth in the 11 western states is continuing to outstrip the national average and the West ($2.8 billion) now accounts for one-fourth of total ($10.2 billion) electronic sales and employment in the United States, reports Western Electronic Manufacturers (WEMA). Employment in western electronic companies has reached 215,000. Of this number, 128,000 or approximately 60% are now employed in the Greater Los Angeles area, while 45,500 or 21% are in the San Francisco Bay area. Projected 1961 sales are 14% above the $2.4 billion recorded by electronic firms in the west last year.

About 20% of all generated power is used as dc in d-c motors, electrolysis, metal refining, etc. Up to three years ago, mercury-arc rectifier (ignitron) was principal device for large direct currents above 400 v; germanium and mechanical rectifiers below 400 v (from 1940-1959 about 8 million kw of mercury-arc-rectifier capacity was installed). About 10 million kw of rectifier capacity will be built in next ten years—but most will be supplied by silicon rectifier, introduced only three years ago. Advantages of silicon rectifiers over ignitrons: efficiency, size, simplicity, first cost, reliability. Advantage of ignitron: grid control.

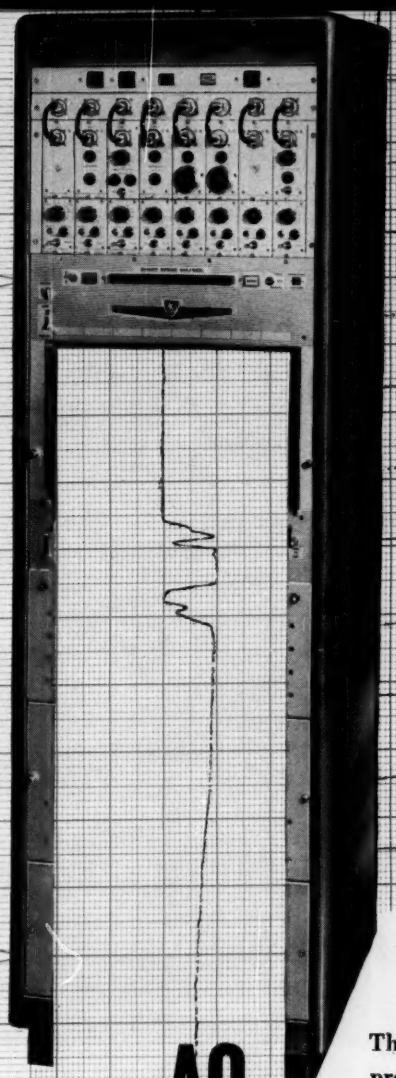
Valve market is approximately $1.5 billion, of which ball valves now have passed the $7 million annual figure, reports Business Week."Independent research outfit" estimates that ball valve market should reach $34 million by 1963, $14 million of which will be in military sales.

Electrical wire and cable market is $1.5 billion in 1960, will be $1.65 billion in 1960, says NEMA.

Bureau of Mines reports that marketed natural gas production for second quarter of 1959 was 2,694 billion cu ft, 6% over the same period in 1958.

Agriculture Dept. reports that government owned surplus crops will reach $10 billion in early 1960; $9 billion is stored.

CIRCLE 34 ON READER-SERVICE CARD ——→



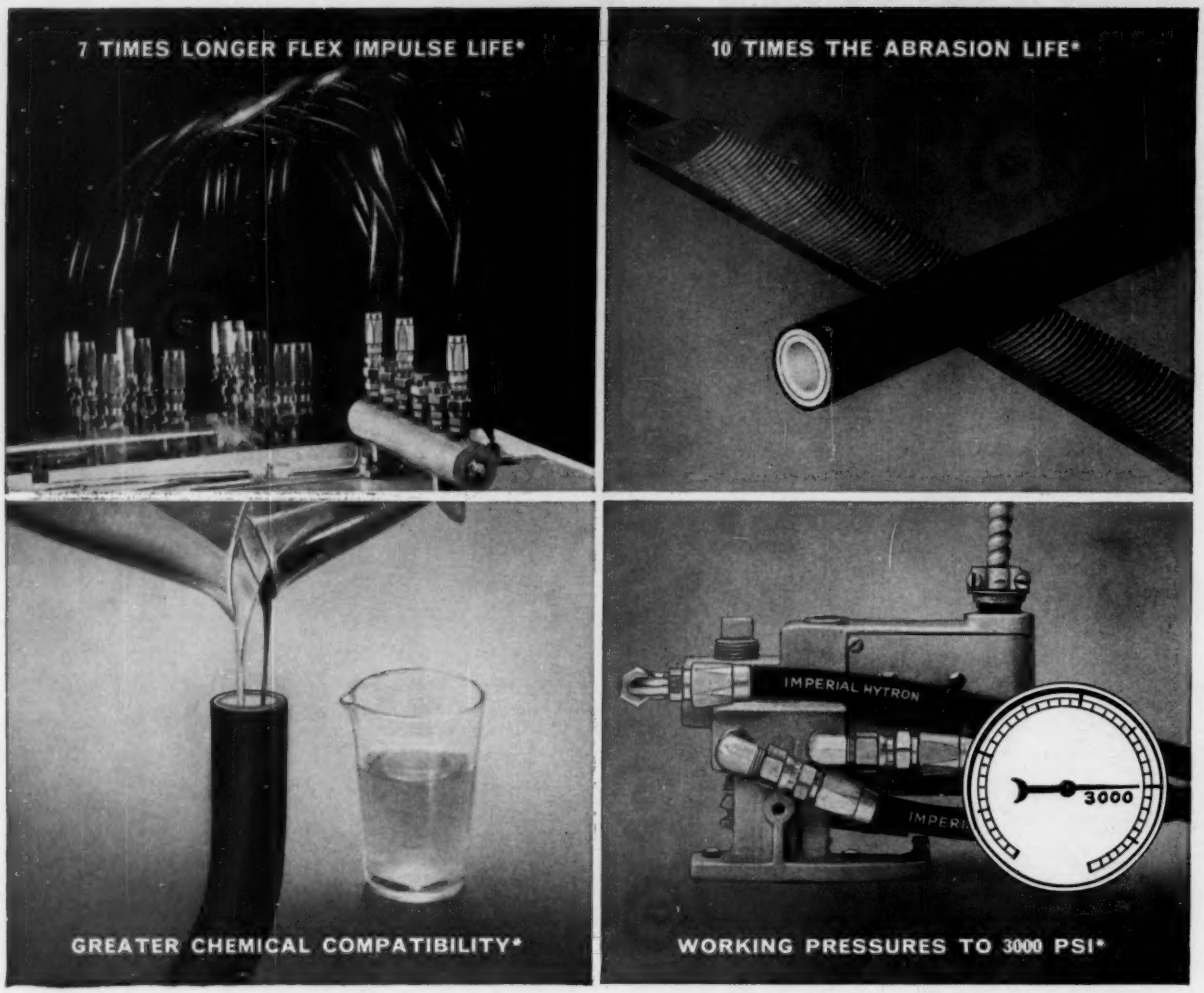
AO Trace-master provides twice the definition

The unique direct-carbon-transfer writing method produces a trace from 2 to 3 times finer than any other direct-writing technique. This allows twice as many lines per millimeter . . . **twice the definition!** Resolution is unsurpassed . . . each line is uniform in width and contrast, revealing the most minute variations in the phenomena measured with utmost fidelity. This writing technique combined with the advanced pen-motor design produces a wider frequency response **at larger amplitudes.** Continuous recording of data can be displayed simultaneously on 8 channels . . . up to 8 independent event markers can be added. Ten chart speeds — 0.1 to 500 mm/sec — provide a 5000:1 chart speed ratio.

The AO Tracemaster has become the new standard of performance for these and many other reasons . . . write now for the full story!

American Optical
COMPANY

INSTRUMENT DIVISION, BUFFALO 15, NEW YORK



No wonder HYTRON® HOSE outperforms wire braid hose . . .

Hytron polyamide-polyester hose takes abuses that make other plastic and wire braid hoses fail. It's tough, durable, lightweight. Has 7 times longer flex impulse life than wire braid. It's versatile. Greater compatibility with mineral or synthetic fluids having a water or phosphate ester base gives Hytron a wider range of uses than other hoses. Available in long lengths, too—to 1000 ft. Some of the hundreds of applications especially suited to Hytron hose include:

Hydraulic lines	Non-conductive (electrical) applications
Hot paint lines	High-lines for electric power
Solvent lines	Fuel and oil lines

High pressure pneumatic and CO_2 lines

***Based on comparative tests with one-wire braid hoses.**

Find out how Hytron Hose can do the job better and save you money. Send for detailed report and test results—Bulletin NEPR-500.

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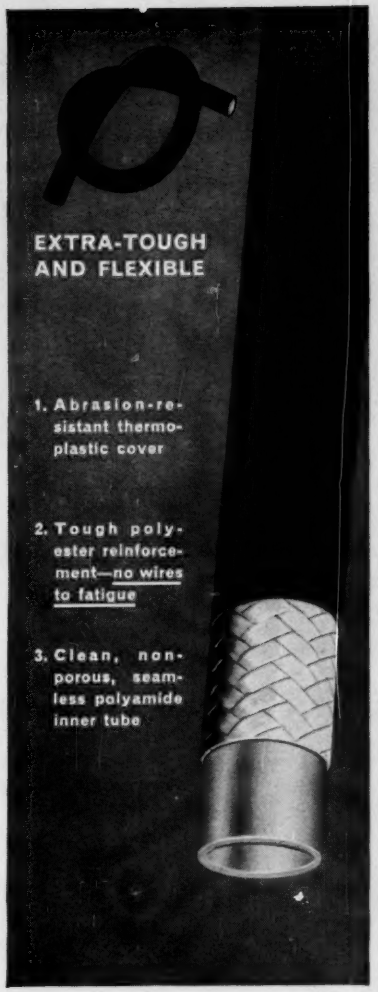
Imperial-Eastman Corporation (Canada) Ltd., Barrie, Ontario, Imperial-Eastman, S.A., Apartado Postal 26544, Mexico 13, D.F.

CIRCLE 35 ON READER-SERVICE CARD


EXTRA-TOUGH
AND FLEXIBLE
1. Abrasion-resistant thermoplastic cover
2. Tough polyester reinforcement—no wires to fatigue
3. Clean, nonporous, seamless polyamide inner tube

it's thermoplastic!

- Highly flexible—minimum bend radius is only half that of one-wire braid hose.
- 60% lighter in weight than wire braid hose.
- Smaller O. D. than same size I. D. wire braid hose—reduces assembly bulk, permits use of more couplings in confined areas.
- More resistant to more chemicals at higher temperatures than standard hose. Resists sunlight, mildew, aging.
- Temperature ranges from −40° to 225° F.
- Low diametrical expansion.
- Over 200 times the torsional fatigue life of wire braid.
- Available in long lengths—up to 1000 ft. Sizes ⅛" to ½".

Hytron hose furnished as factory-made assemblies with permanently attached couplings, or with easy-to-install, re-usable couplings in a wide range of sizes and styles.

IMPERIAL — EASTMAN

IGS EVENTS

October 2-4

Seventh National Communications Symposium, Municipal Auditorium, Utica, N. Y. For information write C. J. Civin, Public Relations, 4 Colonial Dr., New Hartford, N. Y.

October 4-6

Semi-annual Convention and Technical Exhibit, North Atlantic Region American Society of Photogrammetry, Biltmore Hotel, New York. For information write Leo Eichen, c/o Autometric Corp., 331 W. 44th St., New York 36, N. Y.

October 4-6

Process Industries Conference, ASME, Shamrock Hilton Hotel, Houston, Tex. For information write A. B. Conlin, Jr., Meetings Manager, ASME, 29 W. 39th St., New York 18, N. Y.

October 9-11

National Electronics Conference, IRE, AIEE, et al., International Amphitheatre, Chicago, Ill. For information write National Electronics Conference 228 N. LaSalle St., Chicago, Ill.

October 16-17

International Conference on Ionization of the Air, Franklin Institute, Philadelphia, Pa. For information write L. A. Staebler, (Manager Advanced Development for American Institute of Medical Climatology), Philco Corp., Tioga and "C" Sts., Philadelphia 34, Pa.

October 16-19

Eighth Annual Symposium of the American Vacuum Society, Washington, D. C. For information write Albert Nerken, Publicity Chairman, American Vacuum Society, Inc., Box 1282, Boston 9, Mass.

October 25-26

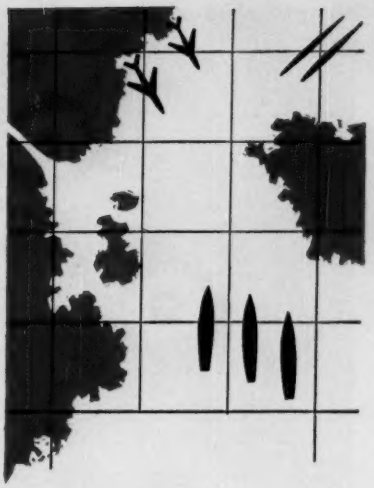
Computer Application Symposium, Armour Research Foundation, Morrison Hotel, Chicago, Ill. For information write Sandra B. Needle, Public Relations Dept., ARFIIT, 10 W. 35th St., Chicago 16, Ill.

October 26-27

Biomedical Engineering Conference, Univ. of Nebraska, IRE, AIEE, ISA, Sheraton-Fontenelle Hotel, Omaha, Nebr. For information write, F. Lowell Dunn, University of Nebraska, Omaha, Nebraska.

November 1-3

Annual SESA Meeting, Hotel New Yorker, New York, N. Y. For information write B. E. Rossi, Executive Secretary, Society for Experimental Stress Analysis, 21 Bridge Square, Westport, Mass.



36 or more fully controllable images from one Kollmorgen projector system

Ships, planes, and submarines to simulate combat maneuvers on battle terrain were required for a naval classroom training device. The problem was taken to Kollmorgen . . . and solved with a unique projector system that can produce up to 36 individual silhouettes of military warfare equipment—fully controllable at any speed, in any direction, and on any screen or wall. Depending upon design parameters, as many as 144 images or more could be provided.

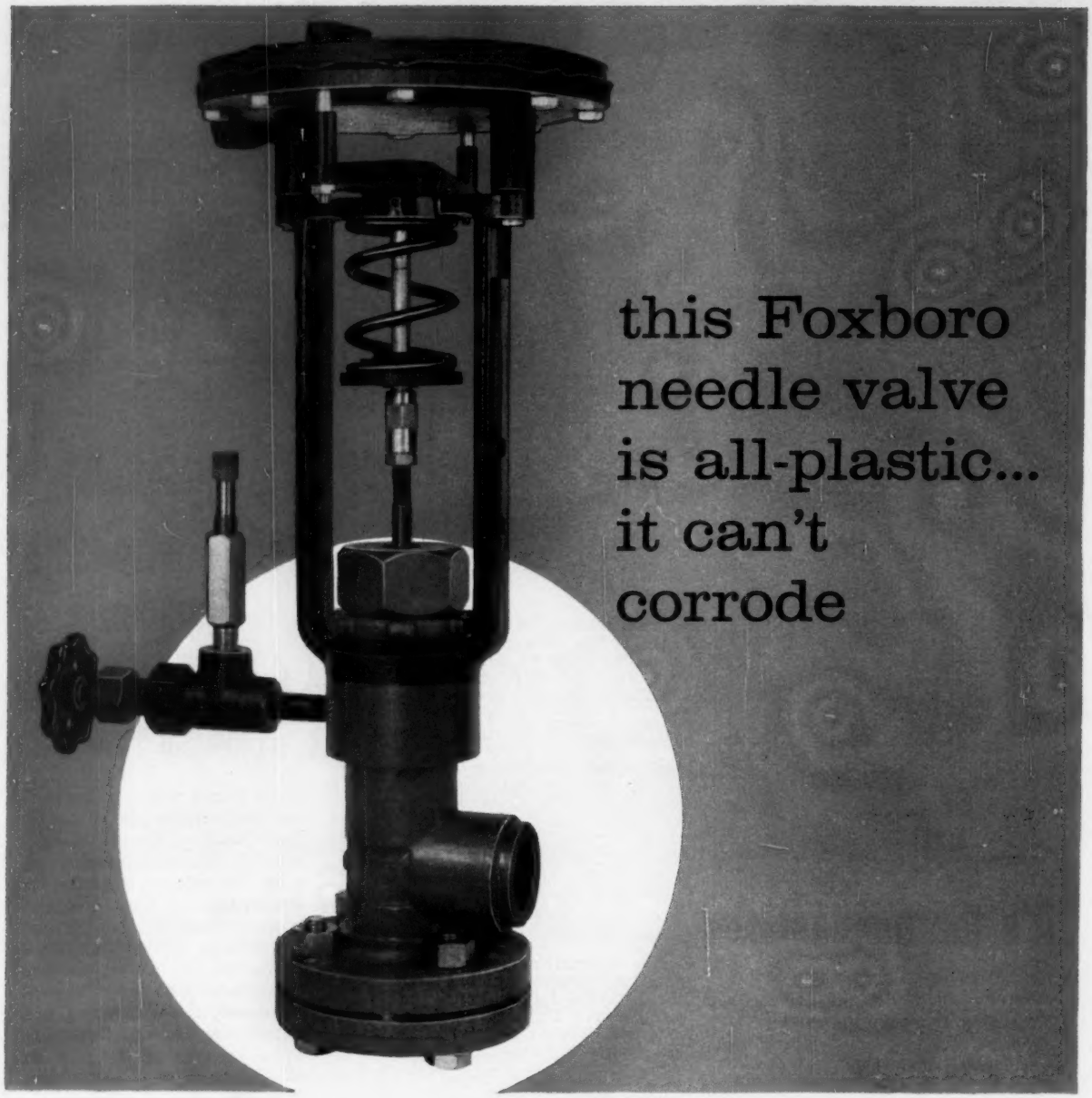
The multi-image projector operates by utilizing a variable number of image projectors to cast preselected images on a screen. A separate projector system provides stationary grids or charts. Thus, images can be maneuvered on simulated battle environments by remote control.

Kollmorgen offers specialized optical/electronic/mechanical skills to meet all kinds of specialized or unconventional requirements. Write Dept. 12-9.

PRESENT US WITH A PROBLEM.

KOLLMORGEN CORPORATION
NORTHAMPTON, MASSACHUSETTS

CIRCLE 36 ON READER-SERVICE CARD



safe...even for nitric, sulphuric, and hydrochloric acids...alums and hypochlorite bleaches

A valve completely fabricated of chemically inert PVC — right down to the valve stem. It's the Foxboro all-plastic needle valve.

Nothing but chemically inert plastic comes in contact with the process fluid. Downtime for replacing corroded valves is eliminated. Smooth, impervious plastic surfaces minimize product build-up.

Foxboro all-plastic parabolic needle and matching seat are produced with toolmaker's precision from normal-impact grade PVC. Even at lowest flow rates, valve will deliver precise control of fluid flows.

Properly applied, and correctly installed, the Foxboro PVC valve will normally last longer than even the most expensive valve of corrosion-resistant alloys. Ask your Foxboro Field Engineer about it, or write for Bulletin 5C-16. The Foxboro Company, 469 Neponset Ave., Foxboro, Mass.

Condensed Specifications

Sizes up to 1 inch
Maximum Pressure Rating
75 psi at 75F
50 psi at 140F
Temperature Rating
140F maximum
30F minimum

FOXBORO
REG. U.S. PAT. OFF.

CIRCLE 37 ON READER-SERVICE CARD

CIRCLE 38 ON READER-SERVICE CARD →

One-inch body diameter
valve line
SKINNER
ELECTRIC VALVES
Completely new series of SKINNER
facilitates further

Here's a really miniature stainless steel solenoid valve with all the features of a larger valve

think small

VALVE SHOWN ACTUAL SIZE

- Now designers of pneumatic and hydraulic control systems and devices requiring high flow in smaller packages can **specify miniature solenoid valves from shelf stock.**
- These new B Series valves are so small and so new that ⅛" NPT was too large, therefore 1/16" PTF connections were selected. Fittings are included to make fluid connections with ⅛" tubing.
- Never before have there been valves like this—**really miniature in over-all size, pipe size, and weight.**

VITAL STATISTICS

Type	3-way normally closed
Over-all size	1" x 2 1/16"
Orifice size	3/64" Inlet and Outlet
C_V factor	.045
Fluid connections	1/16" PTF (adapted for ⅛" tubing)
Weight	5 oz.
Maximum operating pressure	150 PSI
Vacuum	Down to 5 microns

Skinner Distributors are now stocking the first of these new valves—the three-way normally closed. Three-way normally open and directional control, two-way normally open and normally closed, and higher pressure models will be on the market soon.

For complete information contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

B SERIES FEATURES

No leakage—Soft, synthetic inserts provide bubbletight sealing. Seats have smooth rounded edges—no cutting of insert material.

Mounting by means of two tapped mounting holes (8-32) in valve body. Can be mounted in any position.

Voltage—Coils available in most AC and DC voltages. Heat rise meets U.L. standard of 85°C maximum for continuous duty. Maximum power requirement—7 watts.

Electrical housings are available with single grommet or ¼" NPT conduit which can be rotated 360°.

Media—B Series valves may be used with all common media including many semi-corrosive fluids.

Corrosion-resistant—Stainless steel body and internal parts.

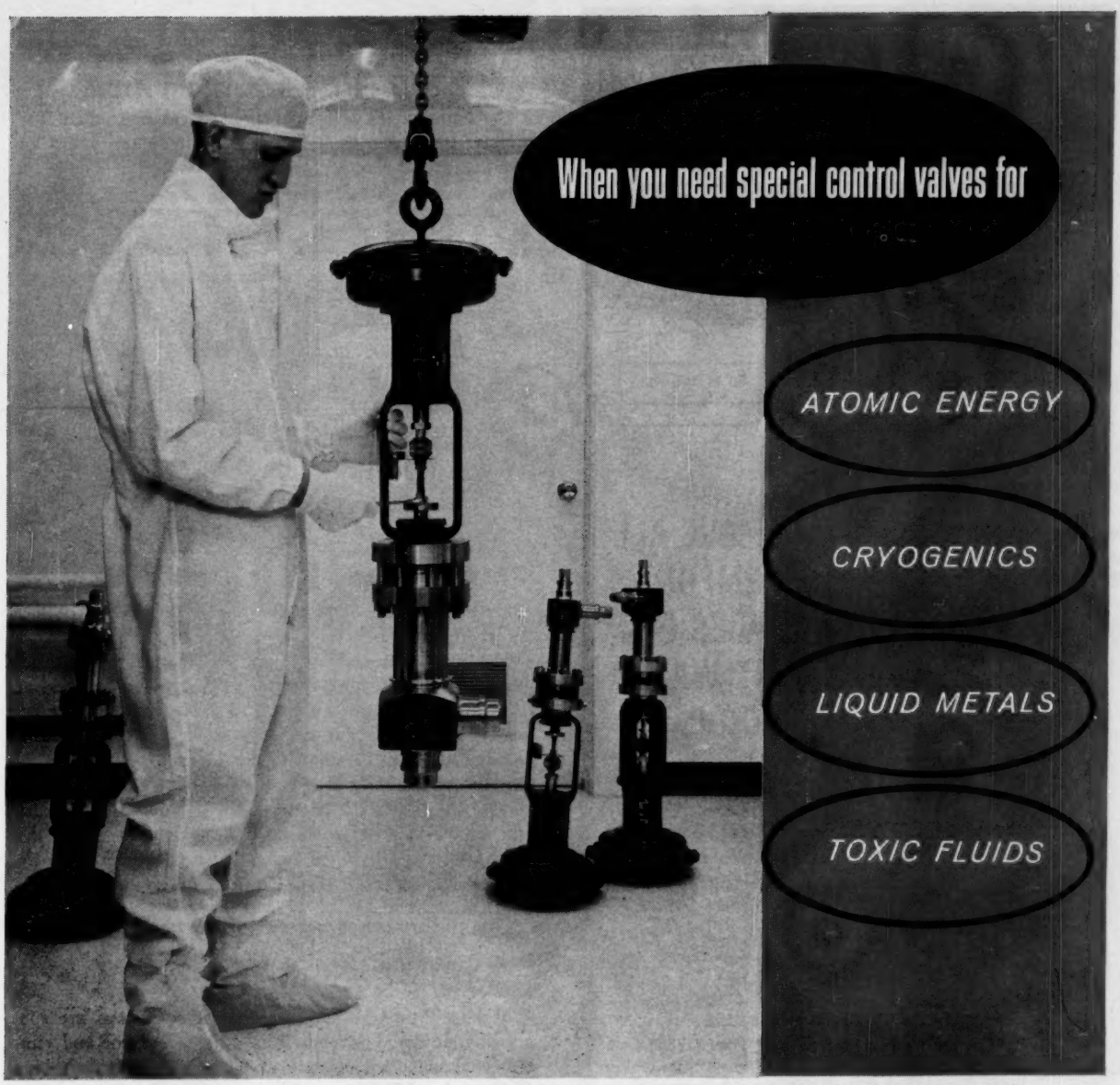
SKINNER ELECTRIC VALVES ®

THE CREST OF QUALITY

SKINNER ELECTRIC VALVES

SKINNER ELECTRIC VALVE DIVISION
SKINNER PRECISION INDUSTRIES, INC. • NEW BRITAIN, CONNECTICUT, U.S.A.

PRINTED IN U.S.A.



Fisher facilities and engineering skill are at your command

Typical of the special control valves assembled in the spotlessly clean Fisher white room is the Type SS-30, a high temperature angle body for controlling liquid metals at pressures up to 250 psi and temperatures of 1500° F. The SS-30 is also used in the atomic energy field and for control of toxic fluids in the chemical industry. Made of forged or bar stock material, the SS-30 has seal-welded joints, Stellite faced valve plug and seat, and bellows seal to prevent valve stem leakage. Stainless steel valve body is self-draining in both vertical and horizontal positions. SS-30 is tested by mass spectrometer when required to meet critical body and seat leakage rates.

Pressurized rooms, filtered air, pre-cleaned tools, and properly attired technicians will keep your equipment immaculate until capped and sealed for shipment. Fisher Governor Company, Marshalltown, Iowa. Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Division: Continental Equipment Co., Coraopolis, Pa.

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER®
SINCE 1880

CIRCLE 39 ON READER-SERVICE CARD

← CIRCLE 38 ON READER-SERVICE CARD

NEW! King COMPRESSED AIR FILTERS

20 to 200 scfm
¼" to 2" NPT

REMOVE ALL HARMFUL TRACES OF DIRT, WATER AND OIL—

GO MONTHS WITHOUT MAINTENANCE!

HERE'S HOW:

1 WET SCRUBBER CARTRIDGE causes mist and fog particles to form large drops that fall off bottom into sump. Takes out dirt, water and oil down to *less than 2 microns*. Self-cleaning; has *almost unlimited service life.*

2 DRY POLISHER CARTRIDGE removes practically the *last remaining traces* of dirt, water and oil; leaves the air *exceptionally clean*. Scrubber does nearly all the work, so Polisher also has *almost unlimited service life.*

These and other features give a *new low in air-cleaning cost*—with a *new high in protection* to air-actuated equipment and processes.

KING FILTER CATALOG gives *ALL* the facts. May we send you a copy?

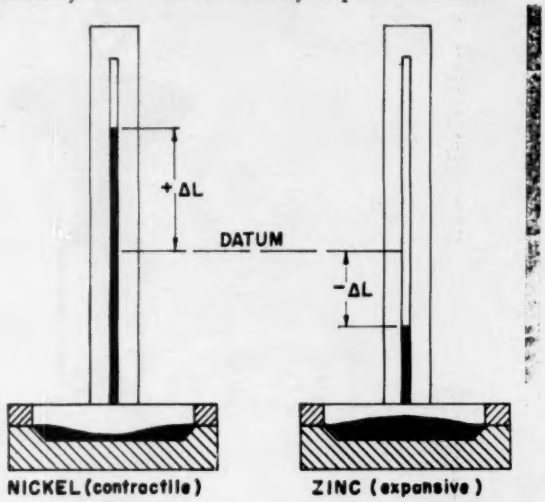
KC INSTRUMENTS
KING ENGINEERING CORP.
3205 S. State St. Ann Arbor, Mich.
LIQUID LEVEL GAGES, MANOMETERS, ACCESSORIES-SINCE 1937

CIRCLE 40 ON READER-SERVICE CARD

BRIEFS—(*Cont. from page* 1573)

Stress in Metallic Films

The Stresometer is a simple, practical instrument for quickly and accurately determining residual stress in chemically and electrochemically deposited metals . . .

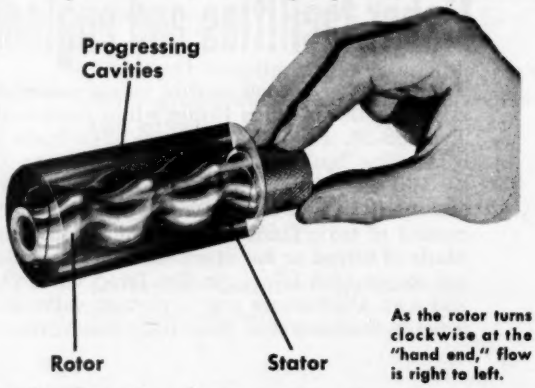


The Stresometer works on a simple principle: A deposit is put down on a thin metal disc (usually made of copper, but other metals may be used as desired or required) from the solution to be tested. Beneath this copper disc, but out of contact with the plating solution, is a metering fluid connected to a precision capillary tube. If a tensile stress is developed in the deposit, the disc "dishes in" slightly which causes the fluid to rise in the capillary . . . (*From new 4-page bulletin, Joseph B. Kushner Electroplating School, 621 S. Norman Ave., Evansville 14, Ind.*)

FOR THIS LITERATURE CIRCLE 212 ON READER-SERVICE CARD

Coolant Pump

Moyno Type CM Special Application Pumps are specifically designed for handling ethylene glycol and similar coolants, . . . operate at temperatures from minus 65° to plus 175°F . . . The pump itself is remarkably



As the rotor turns clockwise at the "hand end," flow is right to left.

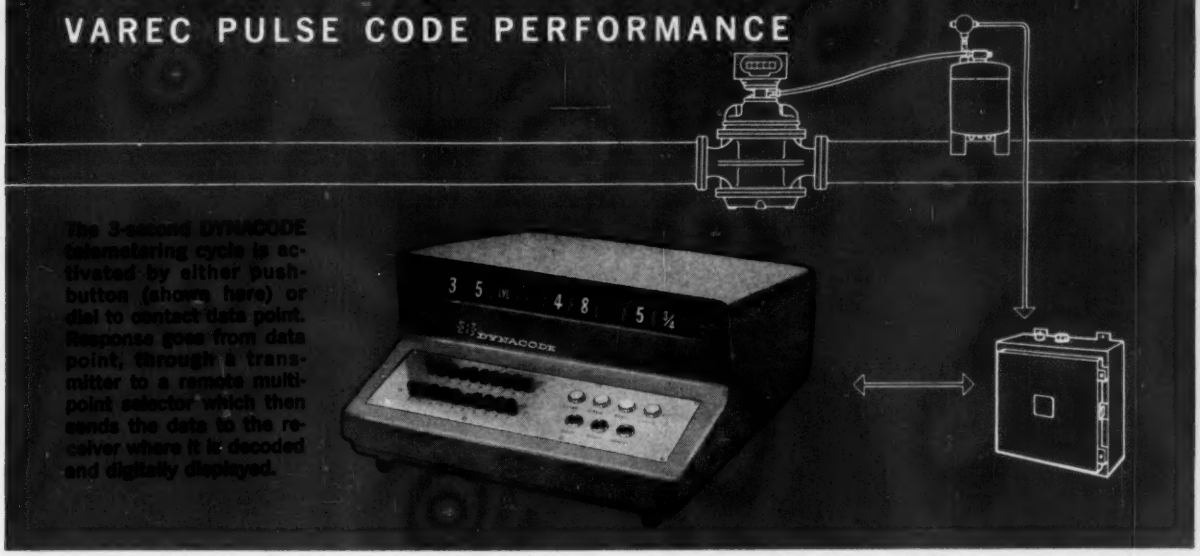
simple in design. It incorporates the famous Moyno "progressing cavity" pumping principle . . . (*From Bulletin 150.5, Moyno® Pump Div., Robbins & Myers, Inc., Springfield, Ohio.*)

FOR THIS LITERATURE CIRCLE 213 ON READER-SERVICE CARD

(*Continued on page* 1592)

DYNEL DYNACODE TELEMETERING SYSTEM

A NEW HIGH-SPEED REMOTE MONITORING SYSTEM BASED ON 6 YEARS OF FIELD PROVEN VAREC PULSE CODE PERFORMANCE



The 3-second DYNACODE telemetering cycle is activated by either push-button (shown here) or dial to contact data point. Response goes from data point, through a transmitter to a remote multi-point selector which then sends the data to the receiver where it is decoded and digitally displayed.

Dynel engineers—utilizing the performance proved concepts of Varec's famous Pulse Code system—have developed the significantly advanced DYNACODE telemetering system for remote readings of liquid level, temperature and P.D.M.

This single-channel, "error-proof" system combines the proven reliability of the basic Varec system with a digital readout time of 3 seconds per point...readout accuracy of 1/16 inch...readout capacity of an unlimited number of points...and readout versatility that permits the system to be tied into a general purpose computer for inventory, billing, and similar functions.

Solid state components are used at key points in the receiver design for longer, maintenance-free life. And DYNACODE, like Varec's Pulse Code, has an instantaneous alarm system without scanning delays.

The high-speed DYNACODE System offers these advantages:

Reliability: Design based on 6 years of performance in scores of pipeline and refinery applications.

Data Display: Illuminated, in-line digital display includes point and function identification, digital data to 6 significant figures and liquid level to 1/16" increments.

Fast Response: data from any given point is gathered and digitally displayed in just 3 seconds.

Flexibility: Designed on building block principle that permits a great variety of system arrangements...DYNACODE is compatible with all standard systems of measurement.

Readout Variety: digital output provides a variety of readouts, including visual display, paper tape, typewriter, etc. Output is compatible for use with general purpose computers.

For complete information, see DYNACODE at the ISA Show, Los Angeles Sports Arena – Booth #170. Or write for Bulletin 301, Dept. ICS-1600-2.

DYNEL, Inc., *a subsidiary of Varec, Inc.*

12923 S. Spring Street, Los Angeles 61, California • Branches and Representatives in Principal Cities

CIRCLE 41 ON READER-SERVICE CARD

"PACKAGED" PROTECTION FOR YOUR CONTROLS

Frame: 24" deep, 24" wide,
63⅜", 70⅜" or 84⅜" high

Front panel space: 56", 63", 70" or 77" high

New Honeywell Modu-Mount* Cabinets

Now you can get standard enclosures to protect your valuable precision instruments and devices. New Honeywell Modu-Mount Cabinets are designed by experts to provide the ultimate in appearance, convenience and economy. Best of all, you can order them to fit your specific enclosure requirements.

The rugged steel frame can be left open or enclosed by panels and doors. You can specify such features as anti-tilt mobile base, wiring trough, lift-bars and eyebolts, or floor levellers, vibration mounting and cooling louvers. And up to five Modu-Mount Cabinets can be supplied with a common base and wiring trough.

Modu-Mount Cabinets come in standard green, grey or brown baked enamel. Other colors are available at your request. For details, call your nearby Honeywell office. Or write Honeywell, Dept. ·-·-··, Minneapolis 8, Minnesota. *Sales and service offices in all principal cities of the world.*

HONEYWELL CUSTOM ENCLOSURES

Honeywell will design and custom-build any cubicle, panel, console or other enclosure to your exact specifications. Special attention is given to these orders, and the finished product meets the most stringent requirements.

Honeywell

H First in Control SINCE 1885

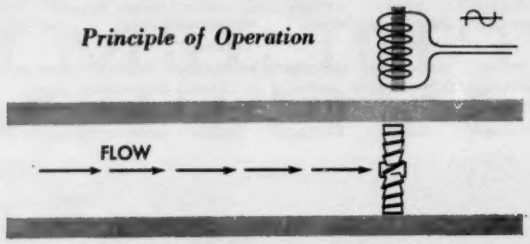
*Trademark

CIRCLE 42 ON READER-SERVICE CARD

Turbine Flowmeters

The turbine flowmeter is a velocity sensing device consisting of a non-magnetic meter body, a rotor freely suspended in the flow path, and an electro-magnetic pick-up. Fluid flowing through the meter makes the rotor turn at a speed proportional to the velocity of flow. As the rotor turns, the blades induce an alternating current in the coil surrounding the permanent magnet in the pickup. The frequency of this current is directly proportional to velocity.

Principle of Operation

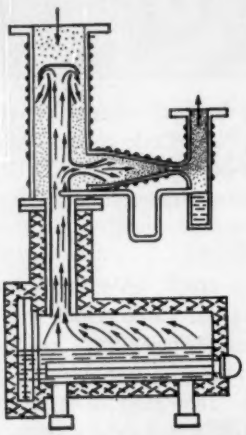


When the meter is calibrated, the output frequency can be used—with proper accessories—for direct flow rate indication, totalizing, recording, telemetering, or used in an electro-pneumatic converter for automatic flow control.—(*From new 12-page Bulletin 1384C, Cox Instruments Div., George L. Nankervis Co.,* 15300 *Fullerton Ave., Detroit* 27, *Mich.*)

FOR THIS LITERATURE CIRCLE 214 ON READER-SERVICE CARD

Hi-Vacuum Vapor Pumps

What is high-vacuum? Technically it is nothing—it is often characterized by the absolute absence of something rather than by the physical presence of anything—and is visualized by modern man to be the absence of atmosphere, of its gases, and their resulting pressures. Scientifically speaking, it is commonly accepted as the condition in a gas-filled space at pressures below one micron Hg (1 x 10^{-3} mm Hg), or roughly one millionth of atmospheric pressure . . .

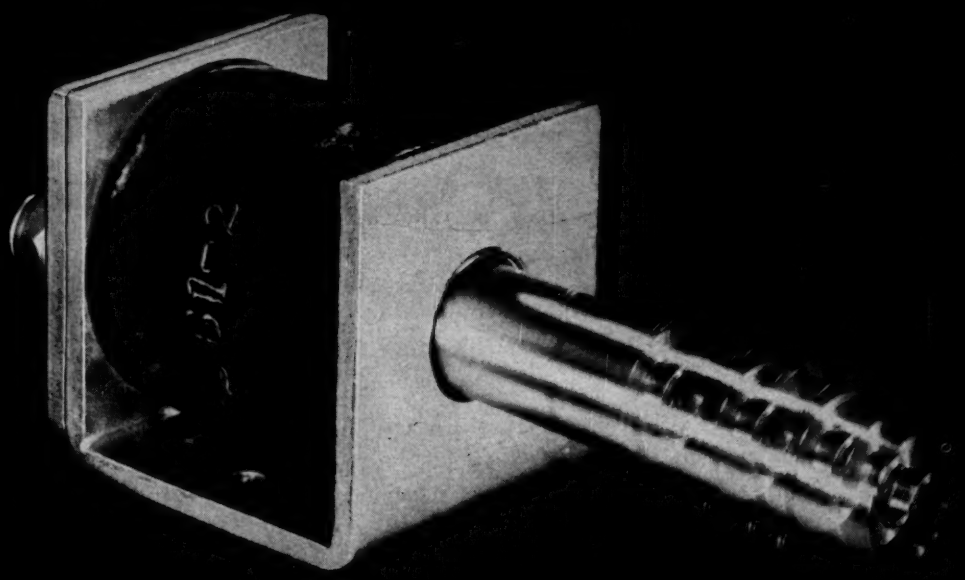


The KS series of four diffusion-ejector pumps was developed to combine the high throughput and the limiting forepressure characteristic of ejector pumps with high-speed operation in the 10^{-4} mm Hg pressure range. These pumps utilize one or more diffusion stages in series with one or more ejector stages. The diffusion stage contributes high pump speed in the 10^{-4} to 10^{-2} mm Hg region, with maximum speeds ranging from 300 to 18,000 liters per second. The ejector stage provides high gas-handling capacity in 10^{-2} to 10^{-1} mm Hg pressure range. It also results in limiting forepressures which increase with the throughput to maximum values as high as 4 mm Hg. Because of these high limiting forepressures, mechanical vacuum pumps, steam ejectors, or water ring pumps can be used as forepumps . . . (*From new* 56-*page Bulletin* 6-1, *Consolidated Vacuum Corp.,* 1775 *Mt. Read Blvd., Rochester* 3, *N. Y.*)

FOR THIS LITERATURE CIRCLE 215 ON READER-SERVICE CARD

(*Continued on page* 1596)

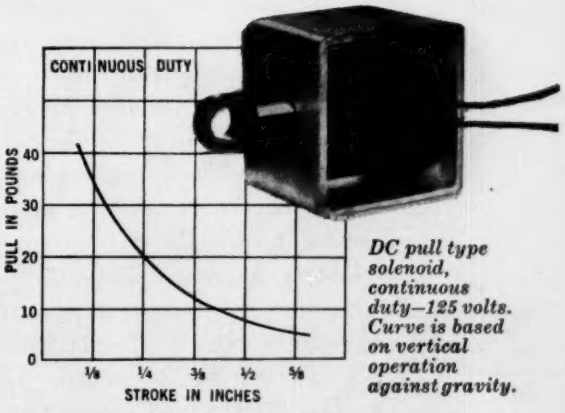
100 MILLION OPERATIONS!



new ASCO solenoid has virtually unlimited life... outstanding economy

In this case "unlimited life" is a simple statement of fact. ASCO's new solenoid is manufactured to such precise tolerances (±0.0005") that wear is virtually non-existent. In ordinary solenoids, the plunger rides loosely in the sleeve—inviting wear. But in ASCO's long-life solenoid, the plunger is guided by a machine tool bearing that assures accurate stroking and reduces friction to an absolute minimum.

Because this solenoid was engineered with quality as the prime consideration, its initial cost is higher. However, it is in fact *the most economical solenoid you can buy* because, once installed, it can practically be forgotten. This solenoid will still be functioning 100 million operations later—long after standard types have been replaced—and replaced—and replaced. For additional information, contact your ASCO engineer or write for Catalog 57-S5.



DC pull type solenoid, continuous duty—125 volts. Curve is based on vertical operation against gravity.

ASCO Electromagnetic Control

Automatic Switch Co. 52-F HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

CIRCLE 43 ON READER-SERVICE CARD

FOR QUALITY... PRODUCTIVITY ...PROFIT

INSTRUMENTATION FOR AUTOMATION

PROBLEM: how to collect, record and transmit critical fluid flow data more *accurately* than ever before.

SOLUTION: custom-designed flow measurement systems from General Electric.

RESULT: reliable process control, simplified fluid accounting, precision batch blending and loading.

System instrumentation includes: true mass flowmeter, available in 13 standard ranges ■ null balance recorders, a full line of strip and round-chart ■ new telemetering equipment, analog and digital.

In addition, ticket printers and totalizing counters are available for visual digital display and pre-set counters may be added to provide precision control in blending and loading operations.

FOR FLUID FLOW PROCESS:

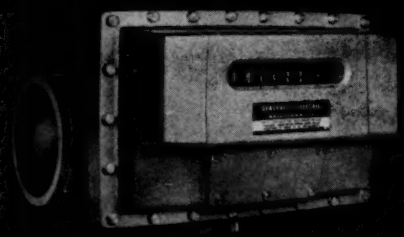
In a variety of system applications, these General Electric instruments cut operating costs and boost plant production . . . through *simplified* and *more accurate* measurement. No wonder they've been specified by process engineers throughout the world. *Performance-proved . . . on the line!*

For complete information, contact your nearby General Electric sales office or write Section 599-08, General Electric Co., Schenectady 5, N. Y. for the following bulletins: GEA-6925, Mass Flowmeter; GEA-6887, Null Balance Recorders; GEA-7163, Telemetering Systems. In Canada, contact Canadian G.E. Co. Ltd., 940 Lansdowne Ave., Toronto 4, Ontario. Outside the U.S. and Canada, contact International G.E. Co., 150 E. 42nd St., New York 14, N. Y.

INSTRUMENT DEPARTMENT

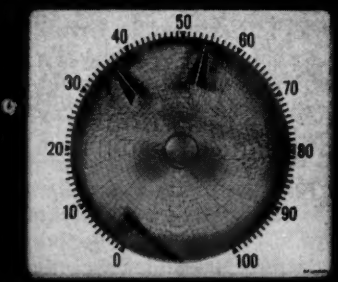
GENERAL ELECTRIC

CIRCLE 44 ON READER-SERVICE CARD

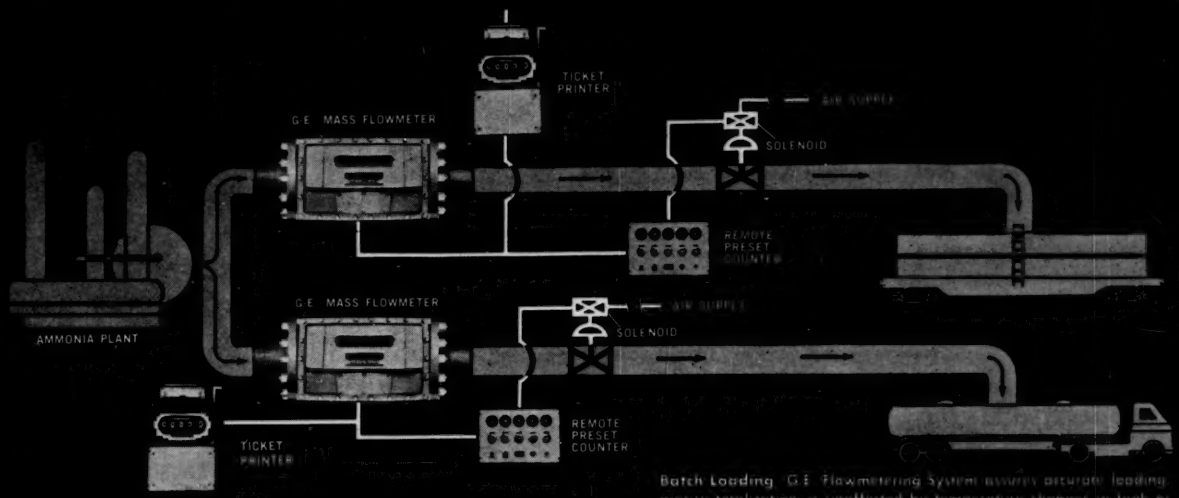


Mass Flowmeter measures fluid flow directly in pounds, eliminates volume-to-mass conversion. ±1% accuracy unaffected by change in pressure, density, temperature, viscosity. Flow rate 13 standard ranges now available.

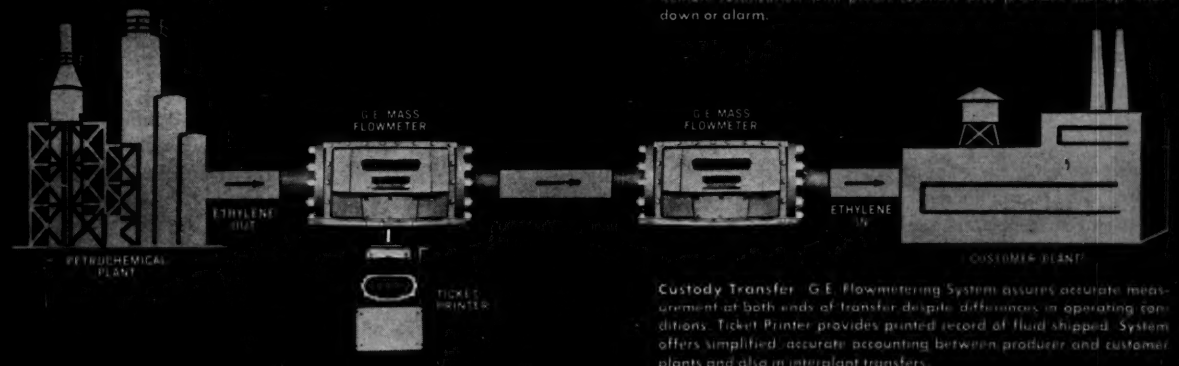
HIGH ACCURACY



General Electric Null Balance Recorders feature: silicon diode reference voltage source for operational reliability; varied control forms for versatile applications; components mounted on swing-out panel to simplify routine maintenance. Full line includes multipoint, single and two-pen strip or round-chart models.

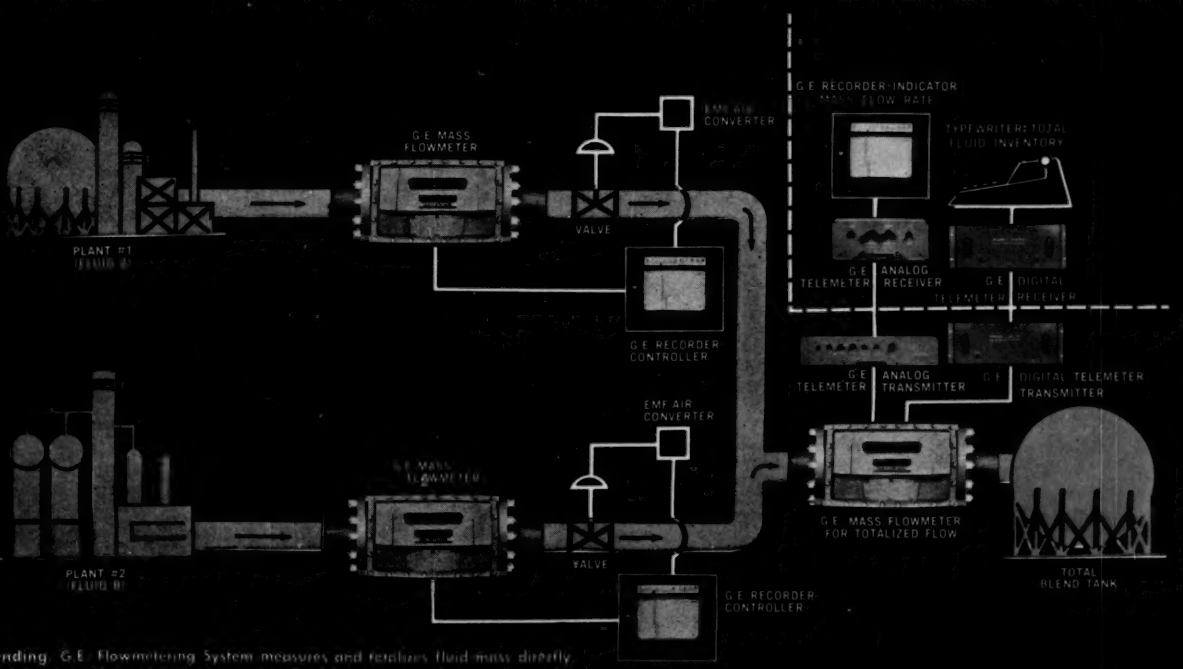


Batch Loading. G.E. Flowmetering System assures accurate loading; precise totalization is unaffected by temperature changes in tank or pipe. Meter measures different fluids with no calibration change. Remote totalization with preset counters also provides startup, shut-down or alarm.



Custody Transfer. G.E. Flowmetering System assures accurate measurement at both ends of transfer despite differences in operating conditions. Ticket Printer provides printed record of fluid shipped. System offers simplified, accurate accounting between producer and customer plants and also in interplant transfers.

MEASUREMENT SYSTEMS FROM GENERAL ELECTRIC

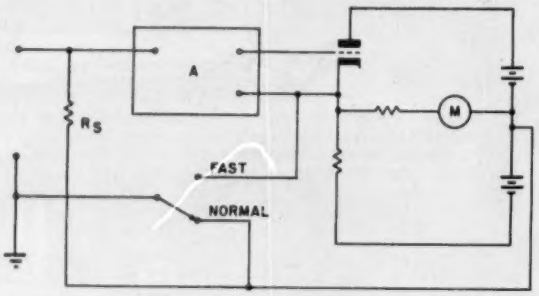


Fluid Blending. G.E. Flowmetering System measures and totalizes fluid mass directly, eliminates laborious volume-to-mass conversions. Predetermining counters assure simplicity and accuracy in blending operations. Data is instantly telemetered to central locations by new G.E. Telemetering. Typical blends are refrigerants, solvents and special naphthas.

Electrometers

An electrometer is a highly improved form of d-c vacuum tube voltmeter. It has all the features of a conventional vacuum tube voltmeter, and it is used to make all measurements that are made with a conventional VTVM. But, in addition, the electrometer has an input impedance greater than 10^{14} ohms and an input stage grid current of less than 5×10^{-14} ampere, making possible a wide variety of measurements not possible with a conventional VTVM . . .

The 200-series battery-operated electrometer volt-

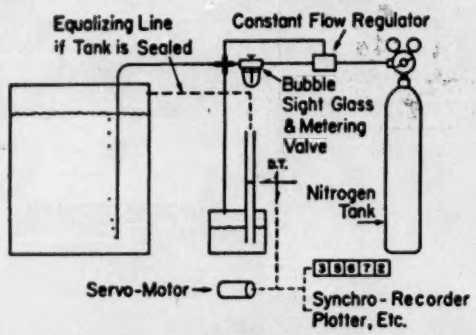


meters feature an input impedance of over 10^{14} ohms and are recommended where only voltages are to be measured, especially potentials above ground . . . (*From new 32-page Catalog Form 35M, Keithley Instruments, Inc.*, 12415 *Euclid Ave., Cleveland, Ohio.*)

FOR THIS LITERATURE CIRCLE 216 ON READER-SERVICE CARD

Servomanometer for Liquid-level Recording

Pressure of the gas in the line at the liquid surface is equal to the head pressure of the liquid at the bottom of the vessel or reservoir where the bubbler line termi-



nates. This pressure is then T'd to a Servomanometer (generally employing mercury as the manometer liquid, but may employ any liquid) which is calibrated in appropriate scale units such as gallons, barrels, pounds, cubic feet, inches, etc. . . . An oil filled sight glass is provided in the line to visually indicate the bubble rate. (In the illustrated assembly the metering valve is combined in the sight glass assembly.) The technique is insensitive to variations in viscosity up to a virtually solid state . . . (*From new 6-page "Memoranda," Exactel Instrument Co.*, 185 *Evelyn Ave., Mountain View, Calif.*)

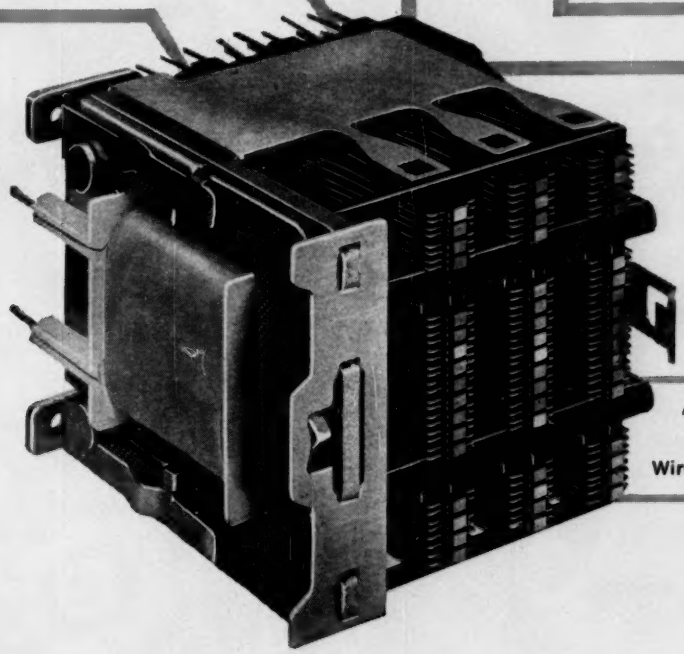
FOR THIS LITERATURE CIRCLE 217 ON READER-SERVICE CARD

(*Continued on page* 1660)

MODEL DC-200AR
Accuracy . . . . . .01% +5 μv of reading
Ranges . . . . . 0-1000v DC
Long Term Stability . . . . . Better than .003%
Reference Stability . . . . . 2 ppm/°C
Price $985*
MODEL DC-100A
Accuracy . . . .05% +5 μv of reading
Long Term Stability . . Better than .01%
Reference Stability . . . . . 5 ppm/°C
Price $475*
±.01% ACCURACY
CALIBRATION STANDARDS
Self Calibrating DC Voltmeters
Now, in the Model DC-200AR Voltmeter, fine accuracy Voltage measurements with a 6 digit readout. Completely transistorized. This instrument and its companion DC-100A use ultra-stable Zener references. The stability, inherent in both these Voltmeters, make them essential to reliable laboratory and production testing. Only 3 watts of power at 117 VAC required. DC-100A available as a DC-100AR in rack mounting. Write for detailed specifications or contact your local CSC representative.
LOS ANGELES, SMITH-DIETRICH SALES COMPANY • SEATTLE-PALO ALTO, STANLEY ENTERPRISES • DENVER-SALT LAKE CITY, EMF ASSOCIATES • CHICAGO, LOREN P. GREEN & ASSOCIATES • WICHITA, LAWRENCE L. HILL • WALTHAM, MASSACHUSETTS, GEO. GOSTENHOFER & ASSOCIATES • SCHENECTADY, CHARLES A. WINICK COMPANY • NEW YORK CITY (MT. VERNON), CEC ELECTRONIC SALES, INCORPORATED • PHILADELPHIA (LANSDOWNE), HOLDSWORTH & COMPANY • ARLINGTON, VIRGINIA, THE JAY COMPANY • ATLANTA-COCOA BEACH, SPECIALIZED EQUIPMENT COMPANY • CLEVELAND-DAYTON-DETROIT, ELECTRO SALES ASSOCIATES • EXPORT, FRAZAR & HANSEN, LTD.
CALIBRATION STANDARDS CORPORATION
a subsidiary of ROYAL INDUSTRIES INC.
1025 Westminster Ave., Alhambra, Calif.

CIRCLE 45 ON READER-SERVICE CARD

AE



AE Series WQA
Quick-Acting
Wire-Spring Relay

TO THE ENGINEER

who wants to transfer 51 circuits simultaneously

If you need simultaneous transfer of a large number of circuits without fail, take a look at AE's new WQA relay. It will do the work of four or more heavy-duty, general-purpose relays each with maximum spring pile-ups, and sustain 50 million or more operations without readjustment.

In the WQA relay, all moving springs pass through holes in a unique actuating "card." Moved directly by the armature, the card in turn actuates all the moving springs. This method of operation pre-establishes exact timing and sequence of all spring operations, and at the same time assures perfectly synchronized "break-before-make" on all circuits.

Contact capacities on WQA relays can be custom-tailored to your needs, with either one, two or three levels of contact assemblies available, each with a capacity of 17 Form C combinations. Other Forms available.

Our circuit engineers will be pleased to work with you in adapting the WQA to your specific design. Or, if you wish, they'll take on the complete packaging job.

If you'd like more information on the WQA relay, address your request for Circular 1957 to: Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois.

AE CAN DO

AUTOMATIC ELECTRIC

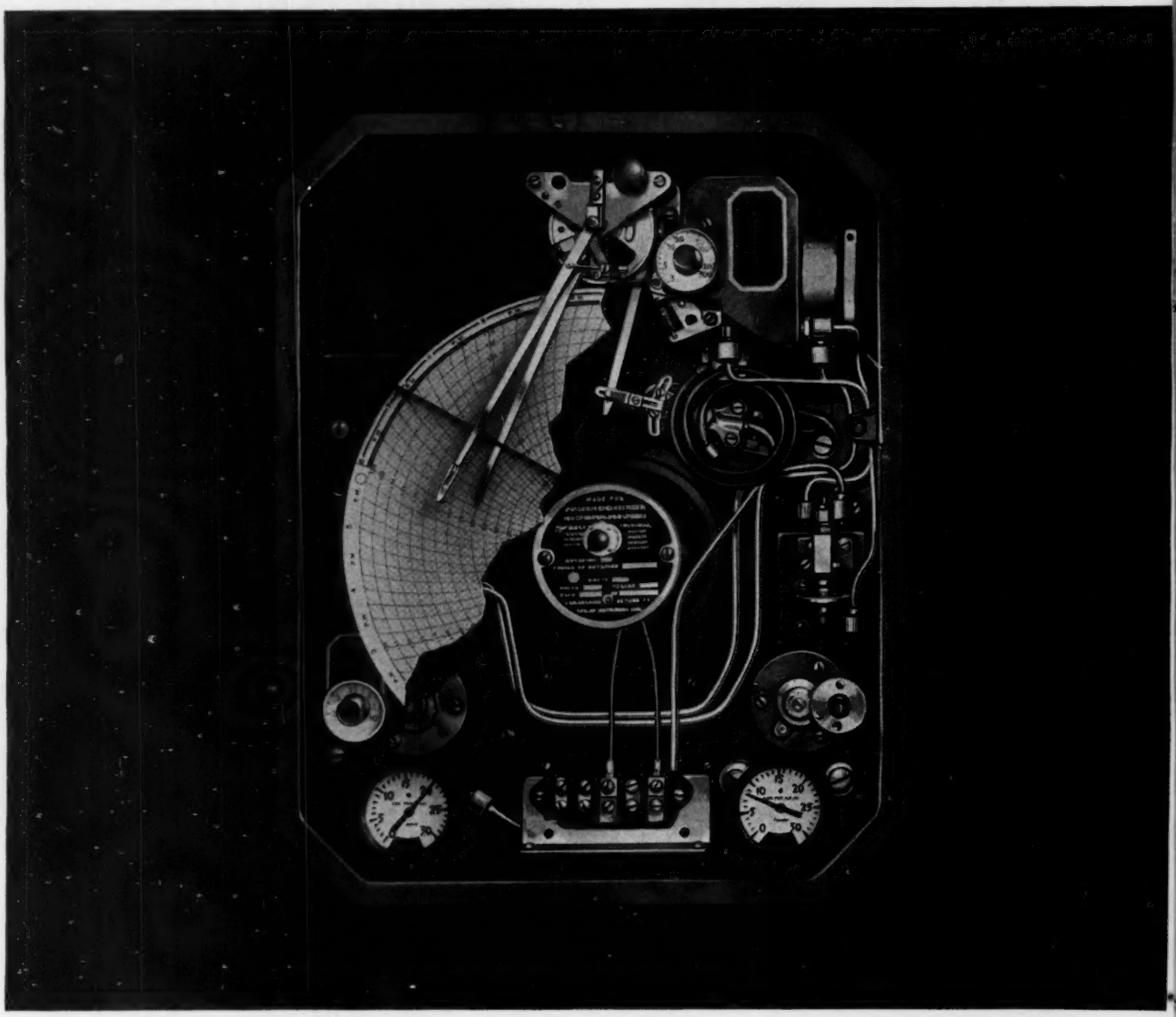
Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CIRCLE 46 ON READER-SERVICE CARD

Tomorrow's tubing technology—today

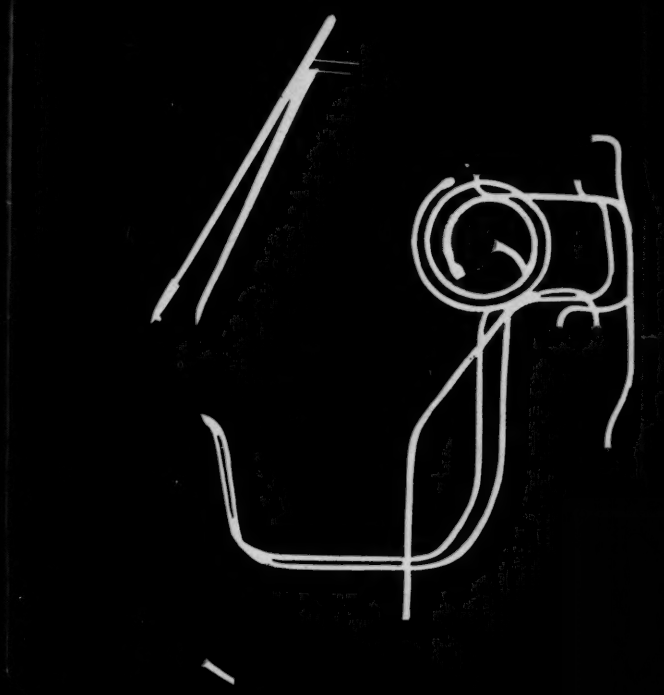


Superior's broad line simplifies selection of small-diameter tubing for instrumentation

Indicating, recording and controlling instruments, more than any other type of precision products, demand fine-quality small-diameter tubing. It can be used for three major applications: (1) as conveyors for the liquid or gas which operates the fluid-filled systems; (2) as strong, light structural elements in linkages, pointers, pen tips and other parts; (3) as special-purpose elements, such as torque tubes, Bourdon tubes, bellows and thermocouple sheathing.

To satisfy the instrument designers' and makers' requirements for small-diameter tubing, we offer a broad line of specialty tubing — thermometer bulb, capillary, Bourdon, torque, bellows, thermocouple protection, fire detection, linkage and recording pen; also tubing for thermocouples and gas chromatography. We offer a wide variety of materials, too. Moreover, we have the metallurgical competence and manufacturing skills to save experimentation in the design stage . . . time and money in production. Bulletin 380, "Specialty Tubing for Industrial Instrumentation," gives details. Write for your copy today. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

CIRCLE 47 ON READER-SERVICE CARD



CAPILLARY TUBING
We have devoted years to the development of manufacturing processes and quality control procedures for the production of close tolerance capillary tubing. ODs range up to 3/16 in., IDs from .004 through .040 in., lengths up to 3000 ft. Analyses include Types 304, 316, 321, 347 and 446 stainless; also Monel,[1] Inconel,[1] nickel and carbon steels.

BOURDON TUBING
A wide range of materials, including beryllium copper, Ni Span C,[1] K Monel,[1] 4130 alloy steel, stainless steels and Inconel X.[1] All are free of inclusions and seams, carburization and decarburization, rough and corroded surfaces, and variations in wall thickness. All offer good creep resistance, low hysteresis, nonrelaxation and excellent fatigue life.

LINKAGE TUBING
Hypoflex,® our stainless steel Type 304 needle tubing, is widely preferred due to high strength and corrosion resistance. Other materials frequently specified to meet particular corrosion requirements are Monel, A Nickel,[1] Inconel and titanium. ODs under .250 in., and walls thin as practicable, i.e., from .015 to .035 in., are usually specified. But any OD, ID or wall within our range can be had.

RECORDING PEN TUBING
Of the Stainless 300 Series, our Hypoflex tubing is most frequently chosen. Other desirable materials are nickel, Monel, Haynes 25[2] and Inconel. Generally ODs from .028 to .050 in., walls from .00625 to .0085 in. are found to promote the best flow rate for ink-carrying systems. In some cases a smaller tube is required for the pen point.

[1]Registered TM International Nickel Company [2]Registered TM Haynes-Stellite Co.

Superior Tube

The big name in small tubing
NORRISTOWN, PA.
West Coast: Pacific Tube Company, Los Angeles, California

Sub-Min.

Widest selection of Pilot Lights -from DIALCO

NEON

T-2

HIGH BRIGHTNESS and REGULAR TYPES

DIALCO's Sub-Miniatures use tiny T-2 Neon Glow Lamps: *NE-2J (High Brightness)* at 105-125 V., A.C.; or *NE-2D* (regular) at 105-125 V., A.C. or D.C.

NEW Series mounts from *FRONT* of panel in 15/32" clearance hole (supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 5 colors; give all-angle visibility. Units are fully insulated; meet applicable Mil. Specs.

Ask for Brochures L-159C and L-160B.

(Illust. approx. actual size)

(Front mtg., 15/32")

No. 137-8536-931

(Front mtg., 17/32")

No. 145-5036-991

(Back mtg., 15/32")

No. 138-3836-1431-99

DIALCO

INCANDESCENT

T-1¾

2-TERMINAL and 1-TERMINAL TYPES

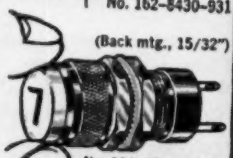
Designed for use with T-1¾ midget flanged incandescent lamps—1.3 V. to 28 V... *NEW* Series mounts from *FRONT* of panel in 15/32" clearance hole—(supplements 17/32" Series). Also—units for mounting from *BACK* of panel in 15/32" clearance hole. Unique lenses in 7 colors. Units are fully insulated; meet applicable Mil. Specs.

Ask for Brochures L-156D thru L-159C.

(Front mtg., 15/32")

No. 162-8430-931

(Back mtg., 15/32")



No. 134-3830-375-7

Spring-mounted Lens-with-Message is *rotatable.*

1-Terminal Pilot Lights

For use on *grounded circuits.* Mount in 13/32" or 15/32" clearance hole. Binding screw or soldering terminal.

(Front mtg., 13/32")

No. 101-4630-971

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Foremost Manufacturer of Pilot Lights

DIALIGHT CORPORATION

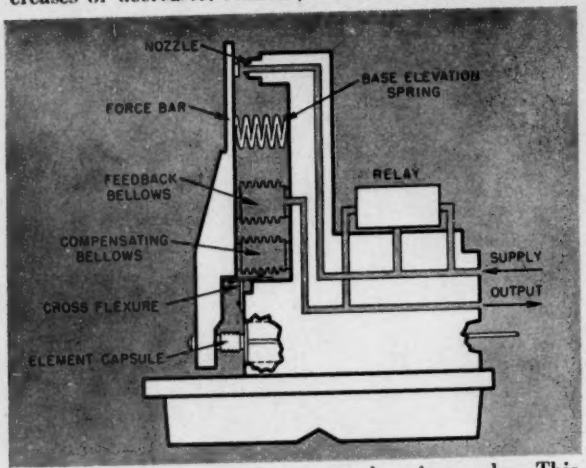
42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

CIRCLE 48 ON READER-SERVICE CARD

Pneumatic Temperature Transmitter

Increasing or decreasing process temperature causes changes in **element capsule** pressure. This changes the force it applies to the bottom of the **force bar.**

The single force bar, pivoted on a **cross flexure,** tends to approach or move away the **nozzle** as temperature increases or decreases. Nozzle pressure increases when the



force bar approaches, decreases when it recedes. This causes relay **output** pressure to change.

These pressure changes are applied to the **feedback bellows** which exerts a balancing force on the force bar proportional to that applied by the element capsule. Feedback bellows pressure, and hence output pressure, is thus maintained in exact proportion to the measured temperature.

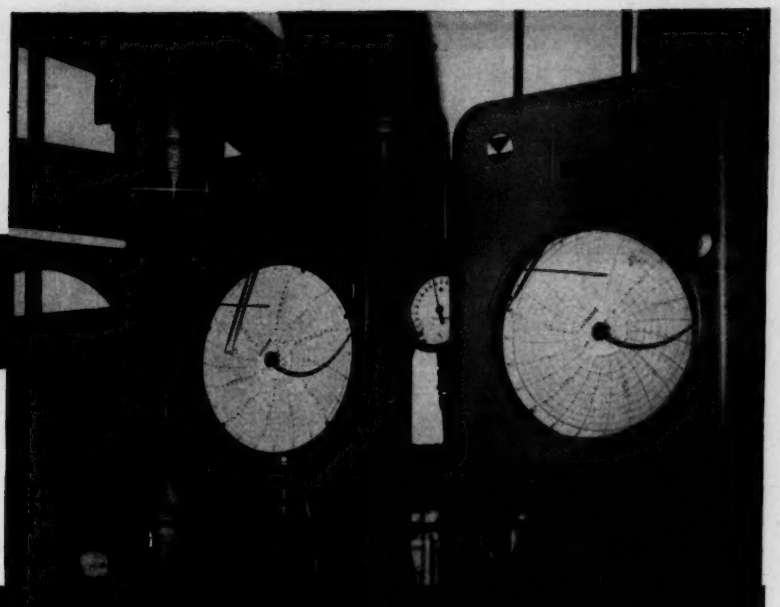
Also acting on the force bar are the **base elevation spring** and the ambient-temperature-barometric-pressure **compensating bellows.** The base elevation spring is adjustable, so that the operating range may be raised or lowered . . . The compensating bellows is acted upon by the same ambient changes that affect the element capsule, and exerts an opposing force to offset the ambient changes . . . (*From* 12-*page Bulletin* 13-17*C, Foxboro Co., Foxboro, Mass.*)

FOR THIS LITERATURE CIRCLE 218 ON READER-SERVICE CARD

Correction:

In our July, 1961 issue, page 1198, the new Librascope noncontact (magnetic) digital-analog shaft-angle encoder was described. However, the illustration used was of the equally new (but much smaller) contact-type brush-type size 8 encoder. We apologize for the surprise we induced in many circles for this error.

(*Continued on page* 1604)



American Integrating Orifice Meters, in a duplex setting, measure gas for boiler at Ft. Lauderdale power plant. These meters are equipped with a fixed gear train to provide a direct reading in cubic feet of gas at base conditions.

AMERICAN® instrumentation solves measurement problem for Florida Power and Light Co.

Florida Power and Light's Ft. Lauderdale power plant. Two of five boilers use 45 million cubic feet of gas per day on an interruptible basis, can consume up to 60 million cubic feet daily.

In each of the eight Florida Power and Light Co. power plants throughout the state, several boilers are fueled by natural gas. Florida Power and Light required a meter that provided a direct reading in actual cubic feet of gas used by each boiler. Measurements would then be transmitted by Telemetering to central data-gathering offices.

American Meter Company supplied a modified Integrating Orifice Meter with a counter reading in cubic feet of gas at standard base conditions that solved their unique measurement problem.

Whether your requirements are simple or complex, you can rely upon American Meter's 125 years of engineering experience to give you the dependable equipment you need for years of accurate, trouble-free measurement and control.

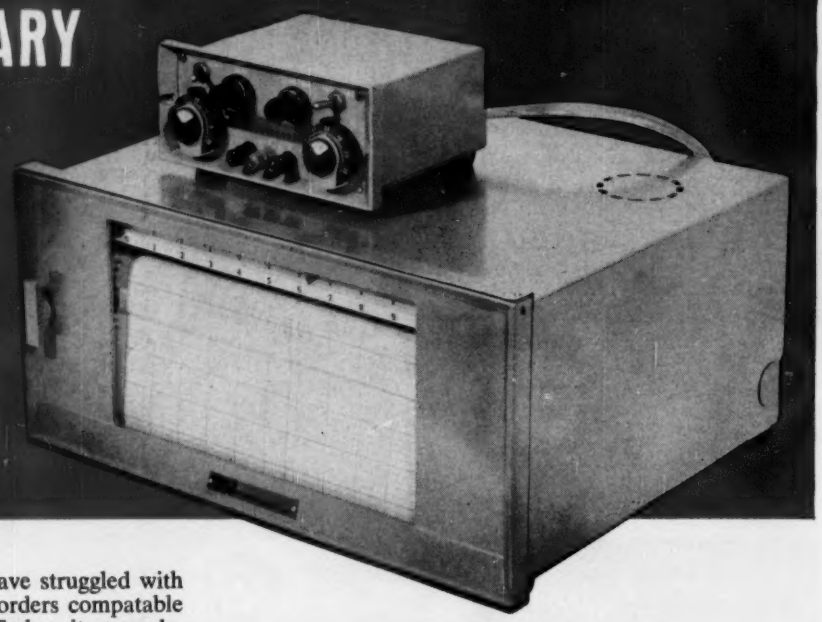
AMERICAN METER COMPANY

GENERAL SALES OFFICE: Philadelphia 16, Penna. • Albany Atlanta • Baltimore • Birmingham • Boston • Chicago Dallas • Denver • Houston • Kansas City • Los Angeles Minneapolis • New York • Omaha • Pittsburgh San Francisco • Seattle • Tulsa • Wynnewood IN CANADA: Canadian Meter Company, Ltd., Milton, Ontario • Calgary • Edmonton • Montreal • Regina Vancouver

GEM

CIRCLE 49 ON READER-SERVICE CARD

REVOLUTIONARY NEW CONCEPT IN RECORDING!



For years instrument users have struggled with making their potentiometer recorders compatable with changing input needs. Today it may be necessary to measure temperature, tomorrow pressure. In order to be prepared to meet these changing demands it has been necessary to stock a number of recorders, or spend hours in modifying existing input circuits.

This costly and outmoded instrumentation is no longer necessary! Westronics, Inc. now brings to the industry a totally new *UNIVERSAL RECORDER* featuring panel or table mounted *EXTERNAL PLUG-IN* input modules. Each has in itself a maximum of versatility.

The Standard Universal Recorder is completely self contained: Ready for millivolt or thermocouple recording (changeable by means of *INTERNAL PLUG-IN RANGE CARDS).*

By simply connecting one of the *EXTERNAL INPUT MODULES* to an existing receptacle on the rear of the instrument, its uses are extended to: *ADJUSTABLE SPAN AND ZERO, RESISTANCE BULB CALIBRATION, STRAIN GAGE MEASUREMENT,* and *MANY OTHER USEFUL FUNCTIONS!*

MODERN DESIGN

Everything about the new Westronics Universal Recorder is modern. Nothing old fashioned about this one! Note these features:

- COMPACT DESIGN (Only 8⅝" high)
- ZENER DIODE STANDARDIZATION
- PULL OUT CHASSIS
- PLUG-IN AMPLIFIERS
- BALL POINT PENS (That Really Work!)
- QUICK CHANGE CHART SPEED SELECTOR (No gears to change)

QUALITY

The new Westronics Universal Recorder features a servo system that uses ball bearings throughout. The pen carriage utilizes ball bearing motion on a precision ground track. No troublesome sheet metal parts sliding on rods on this one. Smooth ball bearing floating action is what makes dependable Ball Point inking practical.

VERSATILITY

The new Westronics Universal Recorder is second to none in versatility. Available in 5" and 11" strip chart sizes, single pen, 2 pen and multipoints.

ALL THESE FEATURES AND A COMPETITIVE PRICE TOO!

CALL ON ONE OF WESTRONICS 23 SALES-SERVICE REPRESENTATIVES TO HELP YOU SPECIFY A WESTRONICS UNIVERSAL RECORDER TODAY.

wi westronics, inc.

TWX FT 8248 U • 3605 McCART STREET • FORT WORTH, TEXAS

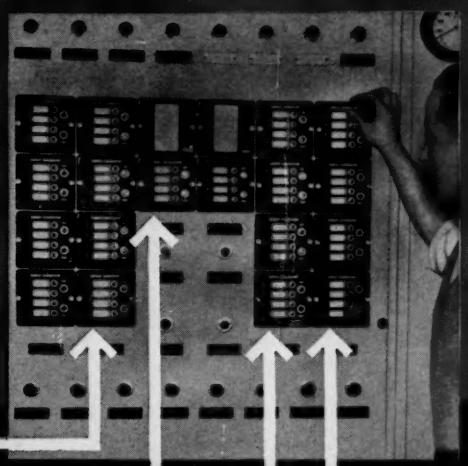
CIRCLE 50 ON READER-SERVICE CARD

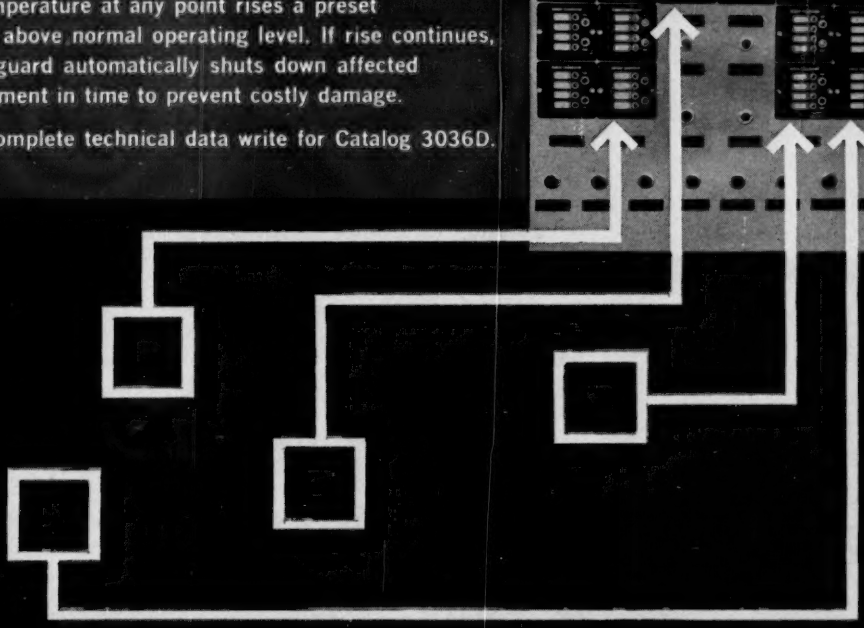
EDISON OMNIGUARD SYSTEM

Transfer of a quarter-million barrels of crude oil is the tough daily quota set for the four pumps and 1500-horsepower engines at the Trans Mountain station, Edson, Canada. To ensure constant, uninterrupted delivery at this heavy flow rate, Trans Mountain engineers specified an Edison Omniguard system to stand watch over critical temperatures in all vital parts of their pumping equipment.

These key points—engine bearings, engine lube oil and cooling water, geardrive bearings, pump bearings, and pump cases—are vigilantly guarded by Edison Model 313N dual-element detectors with both alarm and automatic-shutdown circuits. Omniguard sounds an alarm and visually pinpoints the trouble spot on the control panel if temperature at any point rises a preset 20 F above normal operating level. If rise continues, Omniguard automatically shuts down affected equipment in time to prevent costly damage.

For complete technical data write for Catalog 3036D.

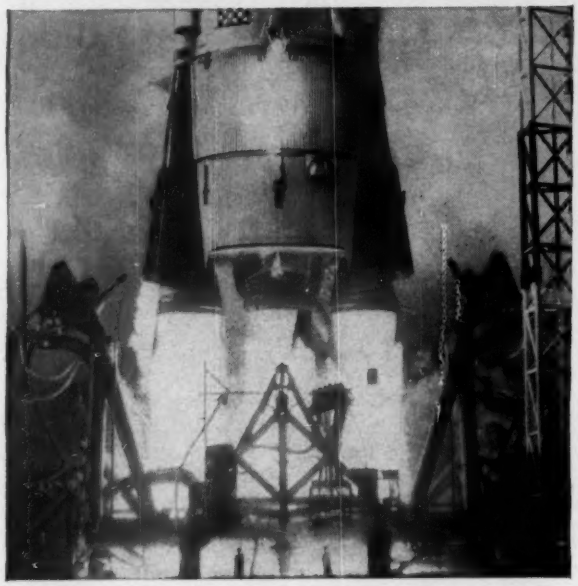


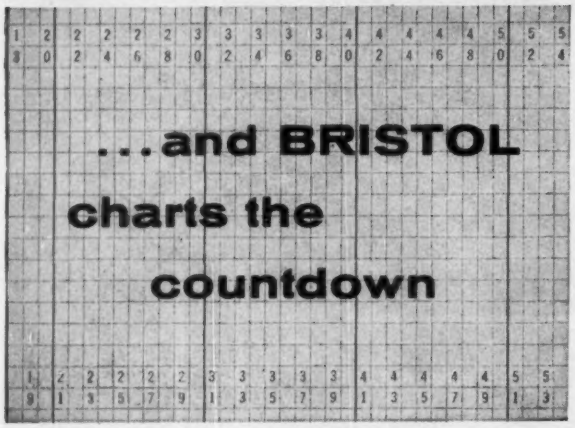


Thomas A. Edison Industries
INSTRUMENT DIVISION
41 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 51 ON READER-SERVICE CARD

ATLAS AWAY!





Bristol charts (sample above) in specially built "time and event recorders" at Vandenberg Air Force Base tell engineers vital facts about the critical moments in the countdown and first few minutes of flight of each Atlas missile.

Printed for Convair (Astronautics) Division of General Dynamics Corporation, prime contractor for the Atlas missile, these charts are just one example of the hundreds of "specials" turned out every year at Bristol chart printing facilities—one of the largest, most complete plants of its kind in the country.

Strip charts up to 32" across, circular charts to 12" diameter can be handled. Standard chart papers of highest quality are available. Or, Bristol can print on a wide variety of special papers, such as papers for metallic marking, foil-type laminates, card stock, heat- and pressure-sensitive, carbon-coated, or photo-sensitive oscillographic papers.

Get in touch with Bristol if you're designing a special recording instrument. An entire special chart engineering service is at your disposal. Or, for more information about this service, write for Bulletin Y1906. The Bristol Company, 154 Bristol Road, Waterbury 20, Conn. B-29

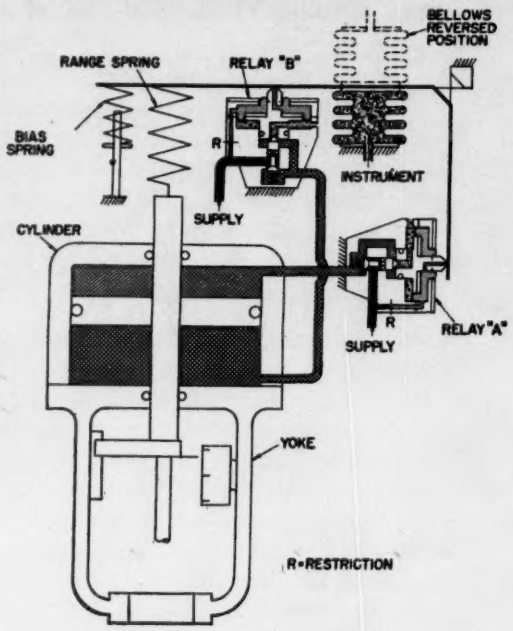
BRISTOL . . . for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

CIRCLE 52 ON READER-SERVICE CARD

Piston Actuators

The pneumatic signal from the controller or instrument is piped to the bellows of the Type 3570 positioner. When the instrument pressure increases, the bellows expands



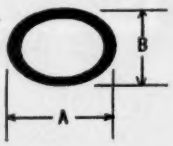
and moves the beam which pivots around a fixed point and simultaneously covers the nozzle of relay "A" and uncovers the nozzle of relay "B" . . .

Piston movement is fed back to the beam by means of a range spring which is connected to the beam and to the piston rod extension, repositioning the beam in a direction opposite to that caused by the expanding bellows. This feedback arrangement prevents over-correction and insures a definite position of the piston and valve plug for a given instrument signal . . . (*From new* 60-*page Bulletin E*-600, *Fisher Governor Co., Marshalltown, Iowa.*)

FOR THIS LITERATURE CIRCLE 220 ON READER-SERVICE CARD

Precision Glass

If you're having trouble securing the tolerances you need, Garner is equipped to solve problems involving O.D.'s between .350" and .005"—and smaller. In fact,



Roundness = A - B

the smaller the part, the better the capabilities in roundness and concentricity . . . square and smooth end cuts . . . precise control over chip size . . .

Garner maintains large stocks of redraw tubing for sealing to Kovar, molybdendum, Dumet, etc. These stocks are manufactured to custom specifications, and are ready for in-plant processing immediately . . . (*From new* 4-*page brochure, T. H. Garner Co.,* 177 *S. Indian Hill Blvd., Claremont, Calif.*)

FOR THIS LITERATURE CIRCLE 221 ON READER-SERVICE CARD

(*Continued on page* 1606)

Bourns Transducers —Tagged Tops in Every Spec!

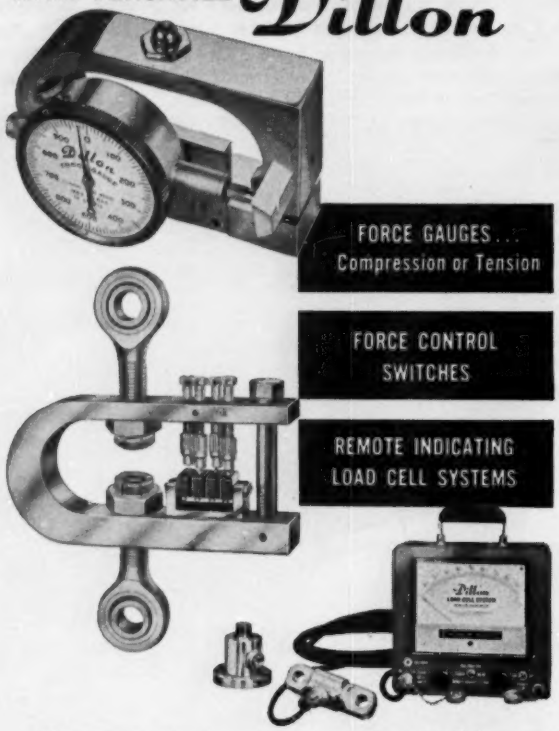
In every measurement of transducer performance, Bourns offers you the top figure. If you're looking for the ideal combination of characteristics, it stands to reason that you'll get it from the company that has attained the highest performance in individual parameters. There may never be an "ideal" transducer; but if there ever is, Bourns will produce it—because Bourns is closest today.

Bourns offers you proven transducers for position, pressure and acceleration. Their reliability is a reality, written in the record of virtually every major U.S. missile and space program, and documented for you in the detailed certificate of inspection and calibration that accompanies each unit.

Pioneers in transducers for position, pressure and acceleration. Exclusive designers and manufacturers of Trimpot® potentiometers.

CIRCLE 53 ON READER-SERVICE CARD

SIMPLIFY TESTING AND DESIGN
WITH VERSATILE *Dillon*



Measure and control mechanical forces ...check dangerous loads remotely!

Whether you are working in tension or compression...or if you must control a specific function at a definite load point...you'll find one of these modestly priced Dillon work tools already tailored to your needs. Secure totalized stresses *remotely* from multiple points on hazardous set-ups. Check the hardness of pellets. Ring warning bells, start motors, control entire automatic production lines... *literally hundreds of applications in laboratory, factory, yard and field.*

PLEASE BE SURE TO MENTION PRODUCT IN WHICH YOU ARE *SPECIFICALLY* INTERESTED. A COPY OF OUR *GENERAL* CATALOG ON *OTHER* DILLON PRODUCTS WILL BE INCLUDED.

368

W. C. *Dillon* & COMPANY, INC.

Dept. 113, 14584 Keswick Street, Van Nuys 79, Calif.

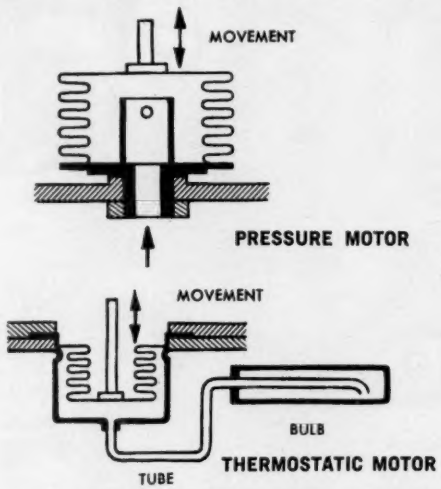
CIRCLE 54 ON READER-SERVICE CARD

ICS **BRIEFS**

Metallic Bellows and Assemblies

The two most widely used types of metallic bellows—hydraulically formed and welded—offer distinct advantages to users. In general, hydraulically formed bellows are fabricated of those metals which are ductile enough to be corrugated into seamless units . . . and are usually less costly to manufacture. *Welded bellows* offer the advantages of a wide choice of weldable alloys and greater precision through extremely close tolerance control of the welded plates . . .

The basic characteristic of a metallic bellows is that it is axially flexible in varying degrees. Essentially, it



can be made to linearly or differentially respond to temperature or pressure changes . . . A relatively new area of interest is the use of metallic bellows in conjunction with electric and electronic circuits. In some instances, metallic bellows assemblies can function as time delay devices, heat controllers, or limit switches, replacing the electronic apparatus customarily used . . . **Pressure Motors**—Convert pressure effects into controlled movement of force. Pressure may be applied inside the bellows or outside the bellows in a cup structure, the latter being preferred. The floating head is usually provided with a limit stop when overload protection is needed. **Thermostatic Motors**—Similar to pressure motors. Pressure supplied by a sealed fill of thermosensitive liquid. Thermal effect may be received either on the bellows element direct or at a remote bulb for transmission through flexible tubing. Widely used to operate valves, switches, etc., in response to temperature changes . . . Formweld assemblies are custom-engineered for each application and thoroughly tested on laboratory equipment, including leak testing on a helium mass spectrometer . . . (*From* 16-*page Catalog* 610, *Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn.*)

FOR THIS LITERATURE CIRCLE 222 ON READER-SERVICE CARD

(*Continued on page* 1608)

CIRCLE 55 ON READER-SERVICE CARD ⟶

POST ELECTRONIC PRODUCTS and CONTROL SYSTEMS

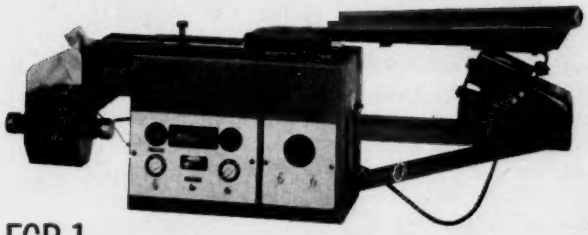
PROVIDE:

AUTOMATION • CONTROL • WATCH DOG RELIABILITY

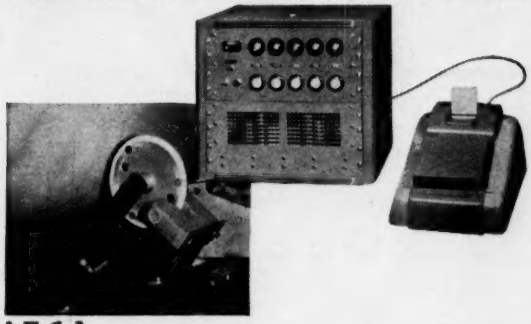
WIDESPREAD ACCEPTANCE is the best evidence of Post's contributions to measurement, and production control. A great variety of problems can be solved by Post electronic products . . . from "batch" counting to paper break detection.

Why not "ASK POST" for an analysis of your particular problem. We will be happy to help you find a solution.

TYPICAL POST DEVELOPMENTS*...



FCB-1 High speed, automatic, small parts counter-batcher. Portable —Feeds, counts and batches small parts, tablets, hardware, etc.

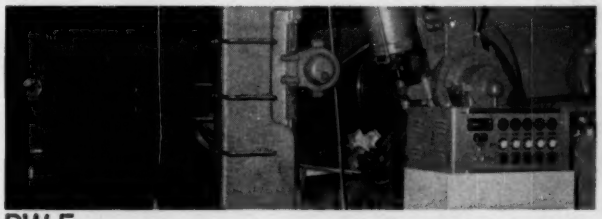


LF-1A Lineal footage measurement, electronically . . . Capable of length measuring continuous production items, i.e., paper, wire, rope, ribbon, etc.

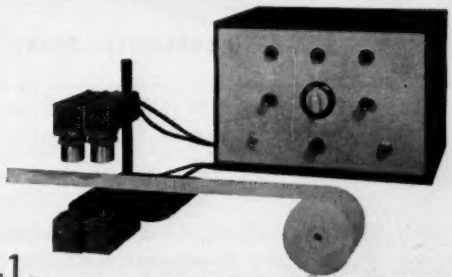
Features visual and printed readout.

P2-RM A preset type counter capable of counting batches in any desired quantity 1-100 (inclusive) with a built-in, 2 scale, rate meter calibrated in "thousands per hour".

PDC The Post "difference" counter . . . capable of maintaining counts of two (or more) variables and acting to control exact difference, i.e., shafts running at different RPM where it's important to maintain "difference" ratio. Many other applications. Adds, subtracts and visually indicates condition.



PW-5 Shown in paper making application. The counter is connected to a lineal footage measuring unit which accurately records paper production. Also provided is a "paper break detector" which will instantly shut off the machine should a web break occur.



ER-1 Edge register detector. Designed to control materials manufactured or processed in a web form. Detects web edge position with extreme accuracy. Inward or outward displacement of web actuates photoelectric control relays for correction.

Get full details on Post equipment today. Check the coupon below.

**These are only a few of the many electronic counters and controls offered by...*

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Division of Reid Brothers Co., Inc.

17 LOTHROP STREET, BEVERLY, MASSACHUSETTS

Your special problems are earnestly requested!

Note: Complete line of production line counters available.

☐	**FCB-1**
☐	**LF-1A**
☐	**P2-RM**
☐	**DFC**
☐	**PW-5**
☐	**ER-1**

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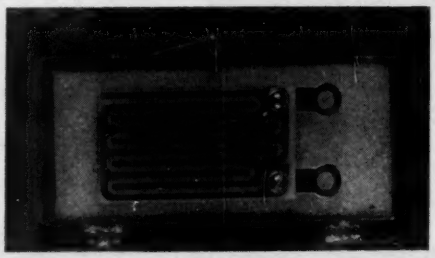
Electro-humidity Transducer

The PCRC Electro-humidity Transducer is an electric hygrometric circuit element which senses changes in relative humidity by changes in ohmic resistance. The trans-



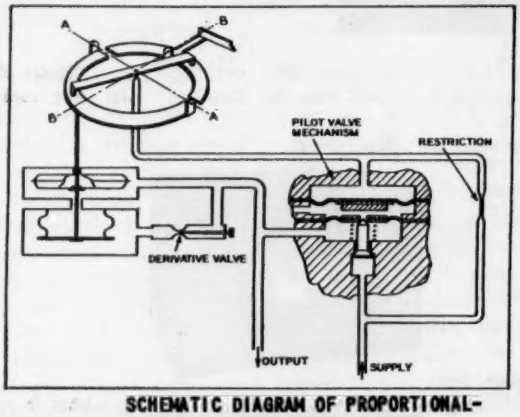
ducer is a processed plastic wafer—a chemically treated styrene copolymer—which has an electrically conducting surface layer that is integral with the non-conducting substrate. Changes in relative humidity cause the surface resistivity to vary .. . Since the humidity-sensitive portion of the sensor is restricted to the surface, water vapor is sorbed or desorbed by means of ADsorption instead of ABsorption; this results in a very rapid speed of response to changes in relative humidity . . . (*From 4-page bulletin, Phys-Chemical Research Corp., 40 E. 12 St., New York 3, N. Y.*)

FOR THIS LITERATURE CIRCLE 223 ON READER-SERVICE CARD

Pneumatic Control Units

New A/D (Advanced Design) Control Units operate as follows:

The measuring element can be almost any standard



SCHEMATIC DIAGRAM OF PROPORTIONAL-PLUS-DERIVATIVE CONTROL UNIT.

high-quality Bristol Measuring Element for pressure, temperature, differential pressure, flow, level . . .

From frequency-response curves, it can be seen that the cut-off frequency of this unit is approximately 400 cycles/minute. This is high compared to the values of 10-50 cpm for most pneumatic units. This high cut-off frequency permits this controller to handle disturbances to the control loop that would upset or pass thru slower-acting units, thus maintaining a more constant value of the measured variable during upsets to the process . . . (*From new 4-page Product Data A*120.4-4, *Bristol Co., Waterbury 20, Conn.*)

FOR THIS LITERATURE CIRCLE 224 ON READER-SERVICE CARD

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"A VIGOROUS USERS EXCHANGE ORGANIZATION"

"unmatched capability in its price class"

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"EASE OF USE!"

WITH THE BENDIX G-15 COMPUTER YOUR EXTRA DIVIDEND IS EXPERIENCE

There's a reason for the continuing leadership of the Bendix G-15 among small and medium-scale computers. The reason is *experience*... for over five years... in nearly 400 installations... in more than 1000 different applications.

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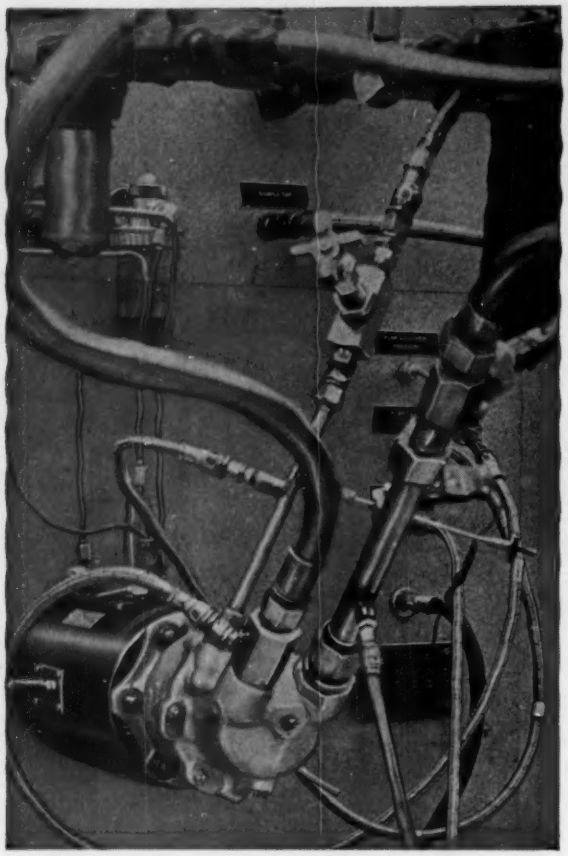

BENDIX BOUGHT THIS TORQUOMETER

When The Bendix Corporation needed torquometers capable of sensing torque on eight production test stands for hot-fluid hydraulic pumps, they chose the B & F Model CB3.

Here's why—

- High Output . . . "gage factor" of 50
- Torquometer alone supports the load
- No adapters . . . Pad Type Couplings (to AND specs.), for ease in changing pumps
- Continuous operation at 350°F

This torquometer can measure up to 10,000 in. lb. of torque, at continuous speeds up to 10,000 rpm. We also produce other Torquometers capable of measuring torques from 0-1 in. lb. to 30,000 in. lb. full scale, at speeds in excess of 20,000 rpm.

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B & F also offers a complete line of Input Conditioners, Digital Logging and Plotting Systems, Temperature Calibrators, Power Supplies, Accelerometers

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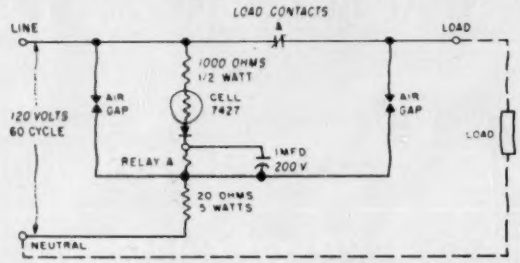
Photoelectric Control for Street Lighting

Operation of the General Electric Quick Response photoelectric control is based on resistance variations of the cadmium-sulphide cell. In the daytime, cell resistance is



low, allowing sufficient current to hold the relay contacts open. As darkness approaches, and light decreases, cell resistance increases. When this resistance is at a pre-determined level, the contacts close, completing the circuit and turning on the lights. In the morning, light levels again increase, lowering cell resistance. The relay is again energized, the contacts are held open, and the lights are automatically turned off . . . (*From new 6-page Bulletin GEA 7230, General Electric Co., Schenectady 5, N. Y.*)

FOR THIS LITERATURE CIRCLE 225 ON READER-SERVICE CARD

AC/DC to DC Comparator

The Comparator is a precision summer-limiter-amplifier-limiter which, among other applications, permits calibration and standardization of ultimate AC and DC standard sources . . . The comparator consists of a set of 0.003% accurate ratio resistors, R1 and R2, for summing the AC input and DC reference signals; followed by a high-speed error limiter, L1, automatic zero reference chopper K, and a precision operational, all-transistor

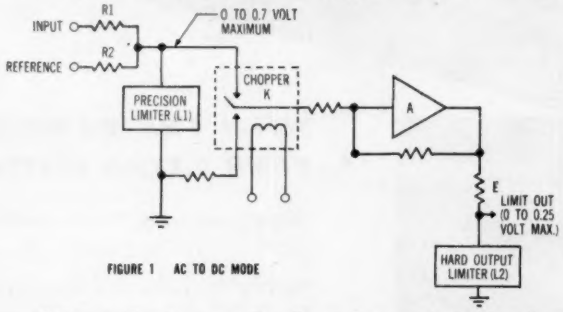


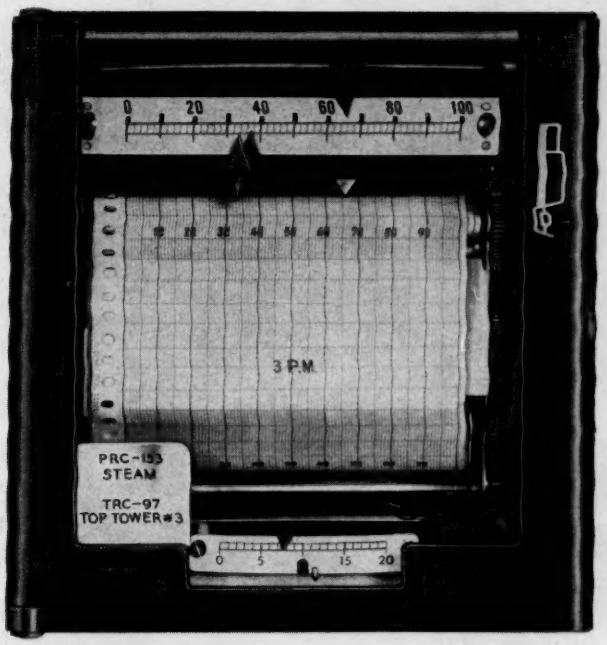
FIGURE 1 AC TO DC MODE

amplifier A. Ratio error for the resistor pair is less than 0.003%, or 300 microvolts out of 10 volts (referred to the input), over the full 0-52°C rated temperature range and a period well exceeding one year.

One half the sum of signals applied to the Input and Reference terminals appears at point E where it is compared to ground by means of the electromechanical chopper K to make system zero-calibration automatic. The signal is then limited in amplitude to 0.7 volt on either side of zero volts by means of high-speed, low-capacitance silicon diodes; after which it is amplified by precision transistor-chopper stabilized operational amplifier A . . . (*From Bulletn 212, Rotek Instrument Corp., 733 Concord Ave., Cambridge 38, Mass.*)

FOR THIS LITERATURE CIRCLE 226 ON READER-SERVICE CARD

(*Continued on page* 1618)



New Bristol Series 670 Metagraphic receivers measure only 7″ wide by 7⅛″ high on panel, come in a wide selection of models, including 1-, 2-, and 3-pen models and models with manual-automatic, manual-cascade, and manual-automatic-cascade control stations.

Now: the USER-PLANNED Receiver *New Bristol Metagraphic*

offers you more features for easy installation, flawless operation, and fast, no-down-time servicing than any other 4-inch-chart pneumatic receiver.

At last, here's the ideal pneumatic receiver for graphic panel applications.

It's Bristol's new Series 670 Metagraphic, the receiver with complete plug-in versatility and convenience, plus these new user-designed features:

Simplified control switching between functions—Allows the easiest start-up procedures for automatic or cascade operation. Just adjust process to line up color-coded indicators and switch to automatic or cascade operation as desired.

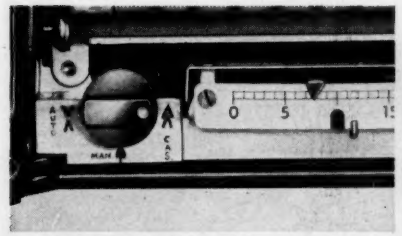
Uniform control switching—All receiver models have the same convenient, easy-to-remember switch positions for the various types of control: cascade position; 3 o'clock; manual position, 6 o'clock; and automatic position, 9 o'clock.

Simplified chart change and inking—Chart changing is a one-hand operation. A new chart can be slipped into place in an instant. The capillary inking system can be filled from the front of the receiver.

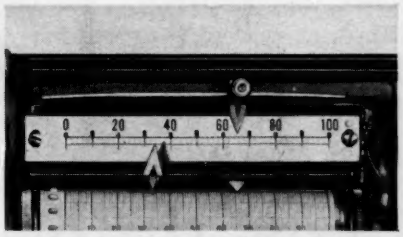
And that's not all: Series 670 gives you such outstanding features as rectilinear chart coordinates for easiest reading, easy connections for any type of control, and sparkless mercury-switch disconnect of electrical circuit when plug-in chassis is withdrawn.

Write for complete data on the new Series 670 today. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn., a Subsidiary of American Chain & Cable Company, Inc. 0.43

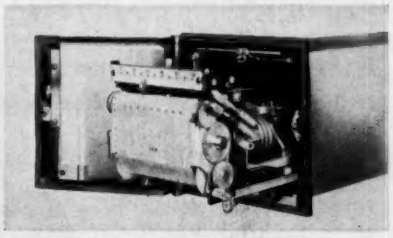
ACCO



Simplified, uniformly-planned control switching facilitates process start-up and operator training.



Brightly-colored distinctively-shaped pointers signal process deviation from set-point, even at a distance.



Complete plug-in versatility—long a Metagraphic feature—insures continuity of service.

BRISTOL...for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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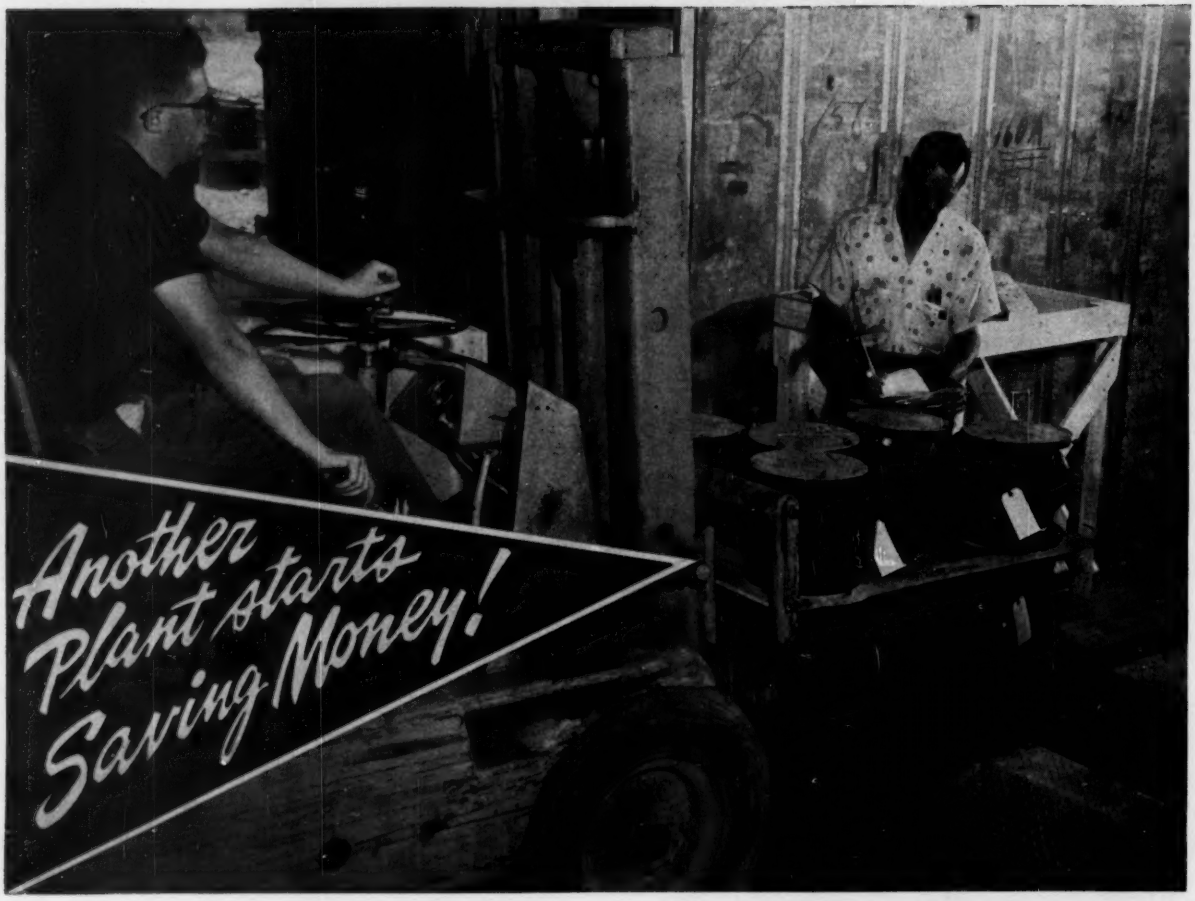

Here's one more plant getting set to install DeZurik Eccentric-Action, NON-LUBRICATED Valves. That means no more leakage-losses, and no more greasing or oiling!

And that means real money saved. Leaks cost money. Lubricants cost money. So do the man-hours to apply them. So does flow-contamination caused by lubricants. So do valve malfunctions if lubrication is missed.

You *DON'T* lubricate DeZurik Valves. Yet their eccentric-principle keeps them absolutely easy-operating, non-binding, friction-free. And they *DON'T* leak, not a drop; they save many, many dollars in the line-losses they stop. They *LAST* longer without wear; they save *MORE* dollars by reducing maintenance and down-time to practically zero.

There's a non-lubricated, easy-operating, money-saving DeZURIK VALVE for just about every service and automated application.

DeZURIK CORPORATION
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ASK FOR CONTROL BULLETIN 150.

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10 years without periodic maintenance!

The reed relays in the new Cubic V-70 series of digital voltmeters assure you of a decade of flawless service. These relays (which replace the stepping switches used in conventional DVMs) have been life-tested for 100 million operations—the equivalent of over ten years of normal operation. The V-70 covers the full DC range from 1 millivolt to 999.9 volts. Balance time is 500 milliseconds; maximum readout time, 750 milliseconds; absolute accuracy is 0.01% plus or minus 1 digit. The meter has no vacuum tubes or moving parts; it operates in any position and is heat and shock resistant; the relays require no maintenance. The V-70 series offers the highest operating speed available in its price range: V-70, only $1,580; V-71 (with automatic ranging and polarity), $2,200. For further information, write to Department IC-108.

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Specially processed wire
for use in SHEATHED
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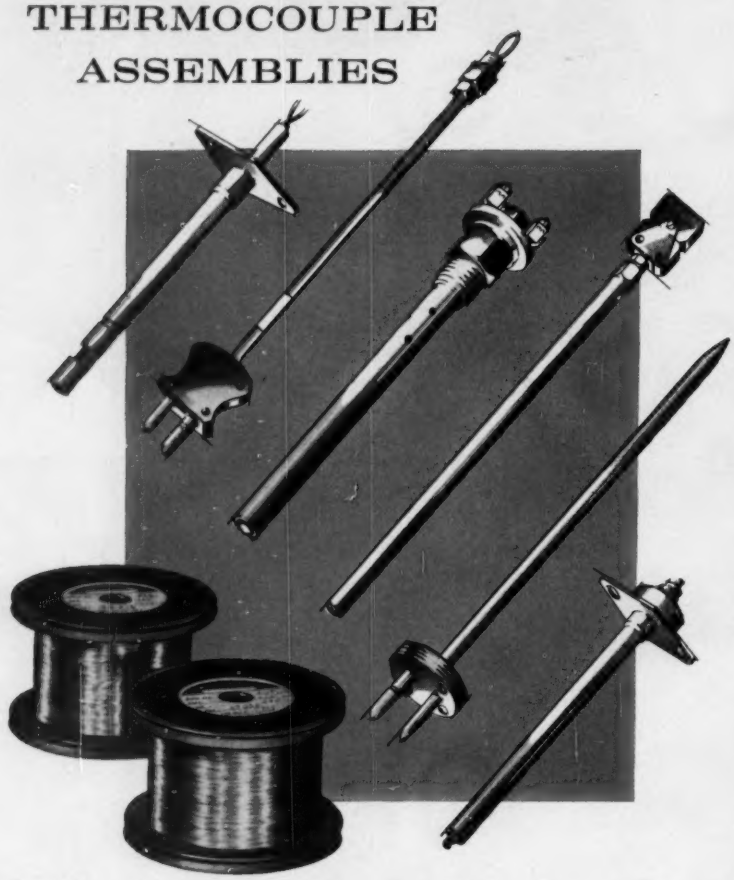
ASSEMBLIES



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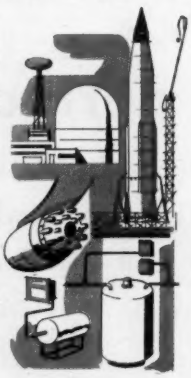
SPECIFICATION 3G-220
THERMOCOUPLE ALLOYS

One good reason for the fine reliability of sheathed thermocouple assemblies—in heat treating and chemical processing applications, jet engines, missiles, and nuclear reactors—has been the development of Hoskins Specification 3G-220 Chromel and Alumel wire. It's a special grade of material produced specifically for swaged, rolled or drawn sheathed unit construction. And all that's required to overcome adverse effects of such cold-working operations on its emf properties is a simple, quick heat treatment after fabrication.



A brand new 36-page catalog-manual contains detailed technical data on this and the complete "family" of time-tested Chromel-Alumel thermocouple, lead-wire, and mechanical grade alloys. Want a copy?

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A NEW ADDITION TO THE SONAC *LINE*

POSITIVE ULTRASONIC LEVEL CONTROL

The components of Sonac (sensor actual Size)

Now, two new ultrasonic sensors, especially for level control have been added to the Delavan line of SONAC sensing and switching devices.

The single sensor system is recommended for liquid level control and the double sensor system for dry level control.

Control is maintained by installing the SONAC sensor through the wall of the vat, bin or hopper. When the oscillation on the face of the sensor is dampened or impeded by the material being sensed, the signal to the control unit changes, activating a relay.

FIG. 1—LIQUID LEVEL (One Sensor)

FIG. 2—DRY LEVEL (Two Sensors)

For level control, SONAC is accurate to .005" and has a response time of 25 milliseconds. Performance of the sensor does not deteriorate with age.

The level control uses to which SONAC can be applied are virtually unlimited. It is not affected by the viscosity*, specific gravity, conductivity, or capacitance of the material being sensed. Temperature or pressure changes of the material do not alter its performance. False signals are eliminated because SONAC may be adjusted so as not to sense steam, foam, or vapors.

*Viscosity may affect response time.

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KNOWLES & FOSTER (North America) Ltd.

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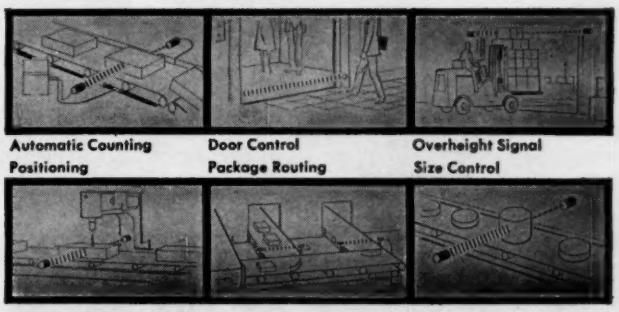
SONAC is extremely rugged. Sensors are type 304 stainless steel. The electronic components in the sensors are hermetically sealed and will withstand pressures to 2000 psi and temperatures from −425° F. to +450° F. They are immune to shock, vibration or mechanical damage.

The control is a compact unit 5" x 5" x 5" and features transistor circuitry. Power consumption is one watt and the unit will operate in temperature ranges from 40° F. to 135° F.

Here's how SONAC can be used for sensing and switching applications other than level control.



Automatic Counting Positioning | Door Control Package Routing | Overheight Signal Size Control

There are dozens of applications for SONAC *single and double sensor units. Let it go to work for you now, write:*

DELAVAN Manufacturing Company

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FROM FAIRCHILD RESEARCH IN SOLID-STATE

A COMPLETE NEW FAMILY...

OF 3S-G SILICON-SEMICONDUCTOR STRAIN-GAGE PRESSURE TRANSDUCERS

Out of continuing research in solid state has come the 3S-G family of silicon-semiconductor strain-gage pressure transducers *with accuracy as high as ±.003% FS/Deg. F* and the new Fairchild d.c. differential amplifier for transducer applications. Tough, tiny, and extraordinarily accurate, the transducers offer the best characteristics of strain-gage and potentiometer-type transducers plus the advantages of piezoresistive silicon-semiconductor sensing elements. ■ Fairchild 3S-G transducers have infinite resolution, self-contained calibration, unexcelled repeatability, and extremely high output signal. Internal temperature compensation from zero to 150° F is standard. Compensation over entire operating temperature range from −65° F to 250° F is available on special order. Designed for new systems and interchangeable with existing military and industrial instruments, they will operate in practically all gaseous and liquid media. Pressure ranges are from 0-10 through 0-10,000 p.s.i.g. or p.s.i.a. Accuracy is as high as ±.003% FS/degree F (error band). Combined linearity and hysteresis is as good as .05% terminal. Standard output is either 50 mv. or ¼ v. or 5 v.d.c. (5 mv. to 5 v. available). The higher output range is especially valuable for transmission over a long line without additional amplification. ■ The Fairchild family of 3S-G pressure transducers includes low-pressure gage and absolute, high-pressure gage and absolute, and high-line low-differential instruments. In addition, there is a zero-drift solid-state d.c. amplifier. Absolute and gage transducers are available in ruggedized and airborne versions. Suppressed or offset ranges are available in all transducers. All have significant applications for precise measurement, testing and control of pressure in underwater, ground support, and airborne systems. All are available from stock for immediate delivery. ■ For more information about Fairchild 3S-G pressure transducers, write Dept. 52ICS.

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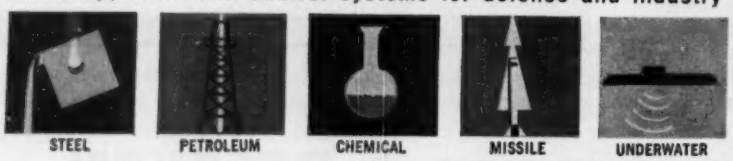
wide application in control systems for defense and industry



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GYROS
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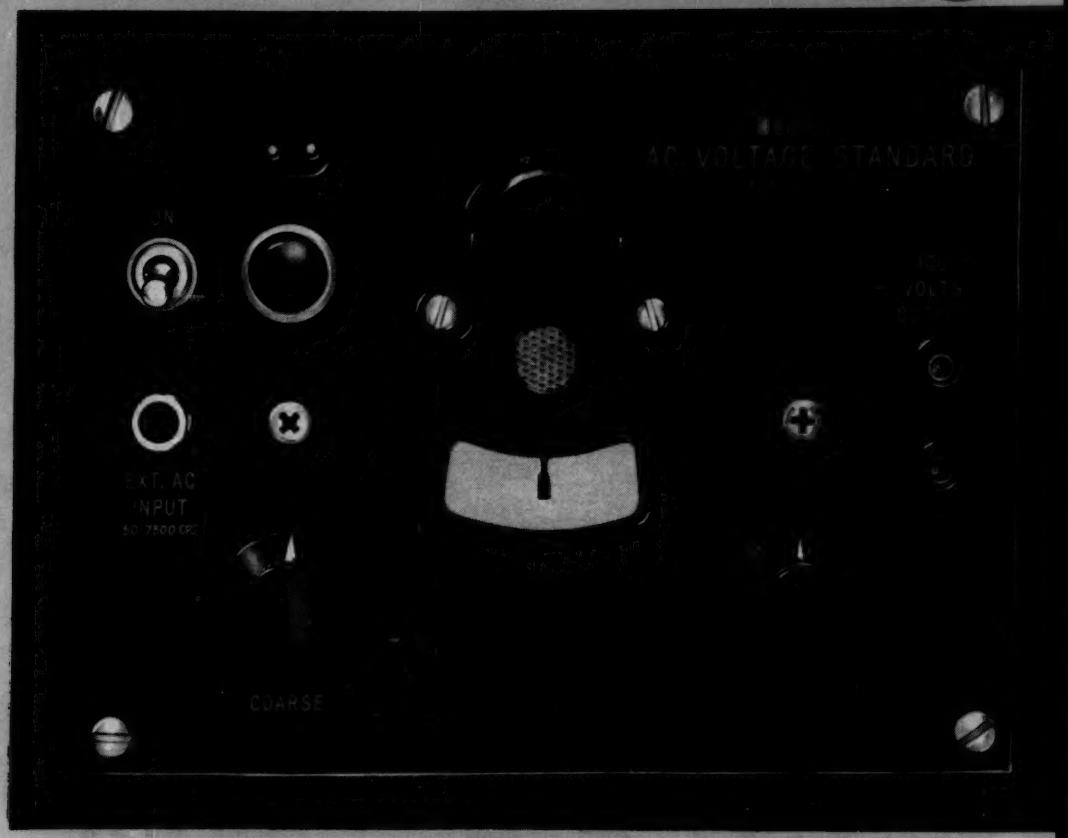
POTENTIOMETERS
ACCELEROMETERS

225 Park Ave., Hicksville, L. I., N. Y.
6111 E. Washington Blvd., Los Angeles, Cal.

CIRCLE 64 ON READER-SERVICE CARD

...until one comes along...



...use this tensor A.C. VOLTAGE STANDARD AS AN A.C. COUNTERPART TO THE D.C. STANDARD CELL.

Application of Model 6010 is as a voltage reference for A.C. calibration work.

The D.C. Standard Cell, developed in 1873 by L. Clark, was finally adopted in London in 1908.

Since 1949 Tensor has had poor J. M. working on an A.C. equivalent. While he has not yet succeeded, the development of the 1N825A Zener reference diode has made this model 6010 Standard possible.

. . . until he comes across . . . engineer J. M. suggests you buy the Tensor model 6010.

SPECIFICATIONS

OUTPUT VOLTAGE:
100 volts

ACCURACY:
±0.1%

OUTPUT FREQUENCY:
60 cps internal or 50 - 7500 cps with external oscillator

CALIBRATION STABILITY:
minimum of three months

OUTPUT CURRENT:
up to 10 ma

INPUT POWER:
105 - 130 volts single phase AC at 60 cps

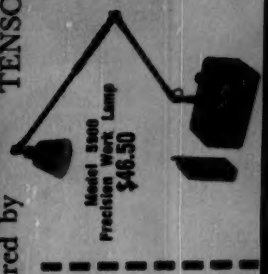
SIZE AND WEIGHT:
8" H x 8¼" L x 6⅛" D — 10 lbs.

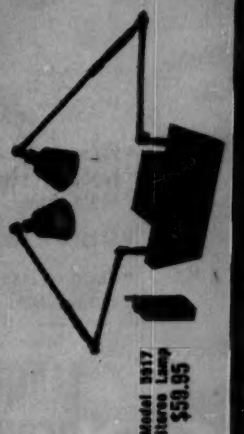
Price: $197.00

CONTACT YOUR TENSOR REPRESENTATIVE, OR WRITE TO US DIRECT
CIRCLE NO. 65

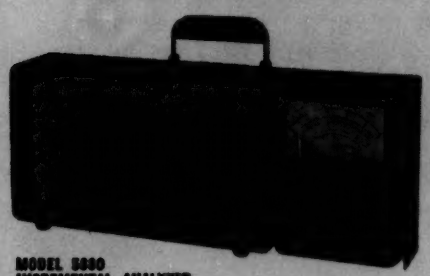
tensor ELECTRIC DEVELOPMENT COMPANY, INC.
1875 EASTERN PARKWAY, BROOKLYN 33, N. Y.

Take a look at the High-Intensity Precision Work Lamps Designed, Engineered and Manufactured by TENSOR.



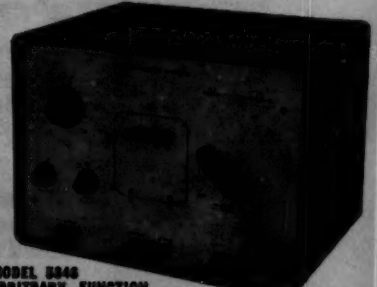


Take a look at other Precision Test Instruments TENSOR Designs, Engineers and Manufactures.



MODEL 5880
INCREMENTAL ANALYZER
CIRCLE NO. 66
Write for Literature

MODEL 5890 PORTABLE REFERENCE SUPPLY
CIRCLE NO. 66
Write for Literature



MODEL 5940
ARBITRARY FUNCTION GENERATOR
CIRCLE NO. 66
Write for literature

NEW *Martin-Decker* **Precision Test Gauge** *makes pressure readings* **25% More Accurate**

8½" Dia. Dial — 25.13" Scale Length
12" Dia. Dial — 36.91" Scale Length

- **Big scale readings in small scale space!**
- **Greater Accuracy!**
- **Requires less panel space!**

360° Calibration makes Martin-Decker Scale 25% longer—gives 25% greater readability than models with 270° scale.

Ni-Span C Bourdon tube is temperature-stable, corrosion-resistant—superior to other alloys.

Tube tip bleed is standard equipment.

Movement calibrated to dial, with an accuracy of ± 0.15% or better.

Uniform linear increments. Protected front zero adjust.

Capacities from 60 PSI to 15,000 PSI.

Find out why more and more O.E.M. designers *specify Martin-Decker Precision Test Gauges for* measuring gas and fluid pressures.

MARTIN DECKER

Write for *Technical Brochure T-59*

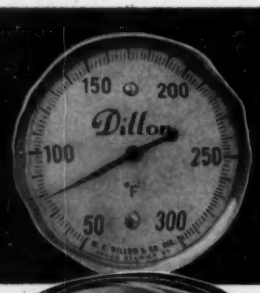
Precision Pressure Instruments Testing—Weighing—Load and Force Measurement

MARTIN DECKER PRECISION TEST GAUGES

MARTIN-DECKER CORPORATION • 3431 Cherry Ave., Long Beach 7, Calif.

CIRCLE 66 ON READER-SERVICE CARD

Investigate the *Dillon* Stainless Steel Thermometer



- Fah. and Cent. ranges for every temp. requirement, gas or liquid
- 1", 1 1/16", 2 5/16", 3", 5" head sizes
- Stem lengths from 2½" to 72"
- Straight form or angle form
- Choice of mounting nuts
- Pressure & moisture proof. Overheat protected.
- Corrosion resistant (bezels & stems made of 316 ss)
- Exclusive bi-metal coil, individual calibration insure utmost accuracy
- Screw-in or surface float
- Special models & ranges to order

YOURS FREE! Engineering catalog describing more than 100 models of Dillon Thermometers and quoting prices. Write today!

W. C. Dillon & COMPANY, INC.

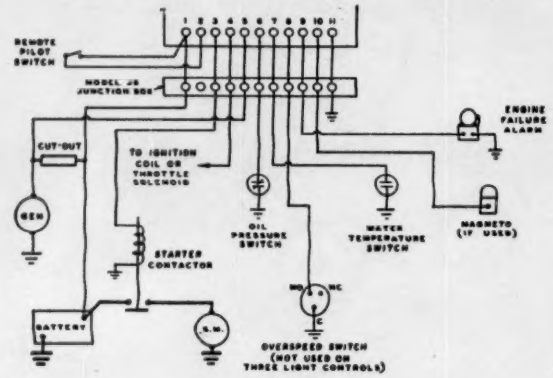
Dept. 113, 14584-6 Keswick St., Van Nuys 79, California

T-42

CIRCLE 67 ON READER-SERVICE CARD

Automatic Engine Controls

Both 46 and 56 Series Controls are designed to automatically start and stop gas, gasoline or diesel engines from the operation of a remote set of electrical con-



tacts . . .

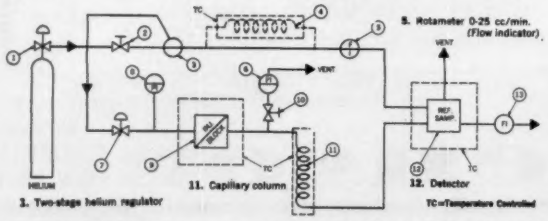
All gasoline or gas engines must be equipped with an *automatic choke to provide reliable starting and efficient* operation under all temperature conditions. On gasoline *engines the choke must be of the thermostatic type which* provides a varying degree of choking under varying *temperature conditions . . . On natural gas engines it is* usually possible to utilize one of our standard solenoids as an automatic choke . . . Generally, the same control sets used on gas and gasoline engines can be used on the equivalent diesel engine; the only difference being the addition of a solenoid operated control to stop the engine . . .

With the control switch in the AUTO position, closing the remote pilot switch will immediately energize the ignition coil or throttle solenoid through Terminal No. 4, energize the starting motor contactor through Terminal No. 3 and unground the magneto through Terminal No. 10 . . . (*From new 52-page Catalog 6, Synchro-Start Products, Inc., 8151 N. Ridgeway Ave., Skokie, Ill.*)

FOR THIS LITERATURE CIRCLE 227 ON READER-SERVICE CARD

Micro Cell

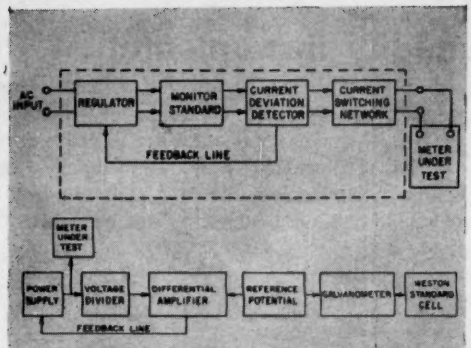
Gow-Mac Micro Cell is a miniaturized thermal conductivity detector of 0.115 cc internal volume in each passage. Male connectors and their seats are designed



for negligible dead space. This new Model JDC-133 has symmetrical gas flow passages. Both sample and reference streams impinge directly under their thermistor beads . . . Sensitivity: Approximately 500 times that of conventional T/C cells, where sample size is limited . . . (*From 2-page Bulletin MI-CE 461, Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.*)

FOR THIS LITERATURE CIRCLE 228 ON READER-SERVICE CARD

(*Continued on page* 1620)



WESTON CONSOLE PROVIDES HIGHEST SPEED CALIBRATION

- **±0.05% accuracy of indicated value**
- **only one operator required**
- **for indicating, recording or digital instruments**

One operator can now calibrate or standardize most types of indicating, digital and recording-type instruments in 1/3 the time previously required by *two skilled technicians*. Designed for speed and simplicity, Model 61 Console is an ideal laboratory standard for periodic testing of other instrumentation.

Precisely adjustable calibration points are provided by this compact unit. AC ranges of 1 through 50 amperes may be subdivided into 30 equal parts . . . and up to 1,500 volts is available in 10 ranges with 75 to 300 divisions per range. In DC calibration, all full-scale ranges may be divided automatically into as many as 15,000 equal parts.

Accuracy of ±0.05% is achieved through proved Weston circuitry and high-precision standard cells. Any load variation, drift or deviation in either input or output voltage is instantaneously and automatically corrected. Phasing of AC units permits calibration of wattmeters at unity power-factor. For limited applications, individual units are available separately.

Call your Weston representative for complete details, or write for Catalog 06-101. Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey.
Export: International Sales Division, 100 Empire St. Newark 12, New Jersey.
In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.

Weston Calibration Console consists of: Models 62 AC Ammeter; 63 AC Voltmeter; 64 DC Voltmeter; and 65 DC Ammeter Calibrators. Power requirement: 60 cycle, 110 to 120 volts. Overall size: 5' high x 7' long x 2' deep.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 68 ON READER-SERVICE CARD

THE ULTIMATE
in testing perfection
Dillon
UNIVERSAL TESTERS

Here's a low cost tester that operates in tensile, compression, transverse or shear. This inexpensive instrument can make *hundreds* of accurate checks daily on metal, plastics, wire, rubber, springs, etc. Handles round, flat or special shapes. More than 15 gripping fixtures available. Max. indicator. Self-aligning grips. Hand wheel operated or motorized. Meet ASTM & Fed. specs. Rugged & fast. Calibrated with certified dead weights. Recorder optional. Max. capacity 300 lbs.

MODEL L. Heavier unit for materials up to 125,000 lbs. PSI. 7 interchangeable gauges provide wide range.

MODEL M. For low strength materials between 0 & 300 lbs. Pendulum-type with 5 scales.

Write For brochures and LOW price schedule today!

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CIRCLE 69 ON READER-SERVICE CARD

INTRODUCING THE NEW
Flowtronic
55 SERIES
AIR VELOCITY
METERS
MODEL 55AI
MODEL 55BI

Rugged, reliable instrument for making accurate direct readings of:

Air Velocity Air Temperature
Surface Temperature

- Eight transistor electronic circuit
- Rapid or damped meter response
- Model 55A1 powered by rechargeable batteries
- Model 55B1 operates on 115v a.c. line
- Electrical output with response from d.c. to 1kc
- **Only $475.**

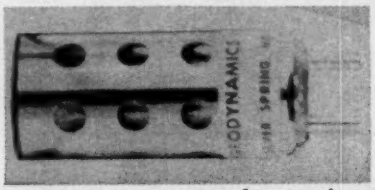
Write for Bulletin 64

FLOW CORPORATION
11 Carleton Street • Cambridge 42, Mass. • TR 6-9843

CIRCLE 70 ON READER-SERVICE CARD

Humidity Instrumentation

The heart of the Electric Hygrometer System is the humidity sensing element, the operation of which is based on the ability of a hygroscopic film to change its electrical resistance instantly with micro-changes in moisture content (relative humidity) . . . Responds instantly to 65% of the total humidity change within 3

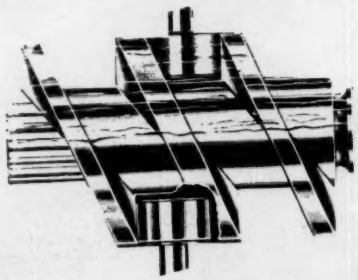


seconds for either an increase or decrease in relative humidity at room temperature. Ideal for continuous study of rapidly changing conditions . . . Two classes of elements offered: Class A, ±1.5% R.H. and class B ±2% R.H. . . Elements are warranted to retain their accuracy for at least one year in normal usage. Field reports of elements in service for over 10 years show numerous cases of retention of original calibration . . . Detect changes as small as 0.15% relative humidity . . . Measurements are reproducible to tenths of a percent R.H. Invaluable in checking gradients, moisture-vapor transmission rates, etc . . . (*From* 8-*page Catalog SF*-1, *Hygrodynamics, Inc.*, 949 *Selim Rd., Silver Spring, Md.*)

FOR THIS LITERATURE CIRCLE 229 ON READER-SERVICE CARD

Adjustable-while-Operating Pump

The Series 300 pumps . . . meet the need for an accurate, controlled capacity unit that can be adjusted while the pump is in operation . . . New cam adjustment mechanism controls the plunger stroke from any point between zero to maximum output of the pump. Stroke

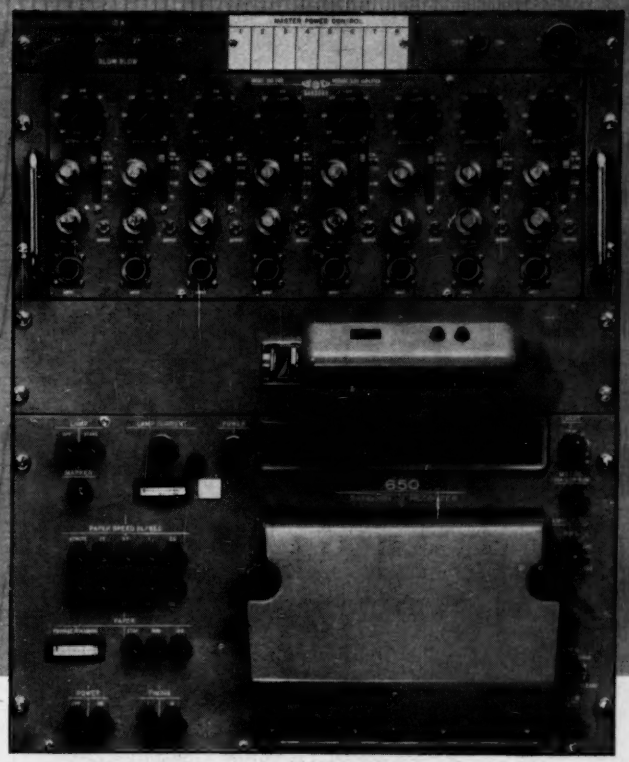


adjustment is obtained by combining the output of two cylindrical sinusoidal cams. When the cam outputs are in phase, the stroke is maximum. When the cam outputs are out of phase, the stroke is minimum . . . The double cylindrical cam is splined to the input drive shaft, thus the cam is free to rotate with the drive shaft and to reciprocate along the drive shaft . . . Rotation of the input shaft causes the double cam to rotate. Because the lower cam follower bearing is fixed in position, the double cam must also oscillate along the shaft in accordance with the shape of the first cam section . . . (*From* 12-*page Catalog*-300, *"Series* 300 *Controlled Capacity Pumps," American Meter Co., Pump Div.,* 13500 *Philmont Ave., Phila.* 16, *Pa.*)

FOR THIS LITERATURE CIRCLE 230 ON READER-SERVICE CARD

(*Continued on page* 1624)

DC to 5000 cycles over an amplitude of 4" peak to peak



NEW SANBORN "650" SYSTEM OFFERS DIRECT READOUT, 8 TO 24 CHANNELS, ALL SOLID STATE CIRCUITS, FOR RACK MOUNTING OR INDIVIDUAL CASES.

Here's the *one* system that lets you record inputs from DC to 5 KC within 3 db at 4" peak-to-peak amplitudes, without changing galvanometers. The "650" system consists of an 8-channel medium gain, general purpose amplifier unit driving a high speed, high resolution optical oscillographic recorder. It can be easily built into your system, packaged in a mobile cabinet or housed in individual cases. The single-chassis, 7" high amplifier module has 8 separate channels, *complete from floating and guarded inputs to galvanometer outputs;* each channel comprises a front end modulator and input transformer, carrier amplifier, demodulator, filter and driver amplifier. Power Supply and Master Oscillator Power Amplifier are built-in. All amplifier elements are plug-in transistorized units for easy servicing.

Immediately readable recordings are made on 8" wide daylight-loading ultra-violet-sensitive charts which require no chemical development. Features of the 12¼" high recorder unit include 9 electrically controlled chart speeds from ¼" to 100"/sec; calibrated monitoring screen; automatic trace identification and timing lines at 0.01 or 0.1 sec. intervals; amplitude lines spaced 0.1" apart which can be blanked from ¼, ½, ¾ or all of chart. Recorder is available with an 8-, 16- or 24-channel galvanometer block which is then equipped with the number of galvanometer elements desired by the customer. Either the Recorder or Amplifier are also available as individual units for use with other equipment.

SENSITIVITY 20 mv input gives 8" deflection; 12 attenuator steps to X5000, smooth gain control.

INPUT RESISTANCE 100,000 ohms all ranges, floating and guarded; DC source resistance must be kept below 1000 ohms on mv ranges only.

COMMON MODE PERFORMANCE Rejection at least 140 db at DC, tolerance to ±500 volts, max.

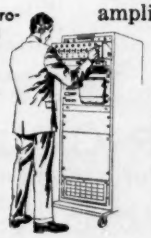
GAIN STABILITY Better than 1% to 50° C. and for line voltage variation from 103 to 127 volts.

LINEARITY 1½% of full scale (8 in.)

NOISE 0.02" peak-to-peak, max.

MONITOR OUTPUT On front panel; provides ±1v full scale across 100,000 ohm load

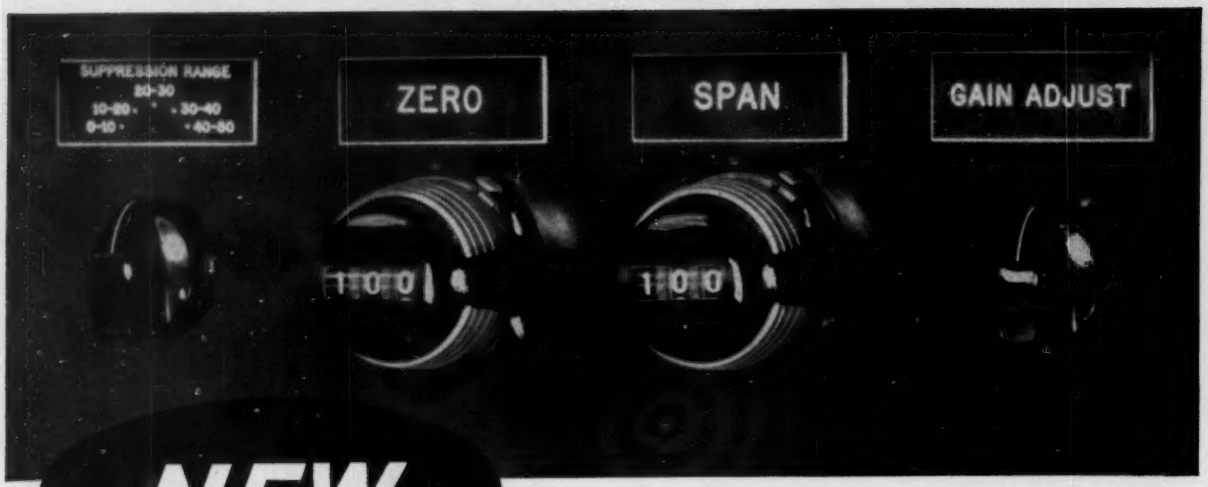
POWER REQUIREMENTS 103-127 volts, 60 cycle AC, 625 watts



Contact your Sanborn Sales-Engineering Representative for complete specifications and applications engineering assistance. Offices throughout the U. S., Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Massachusetts

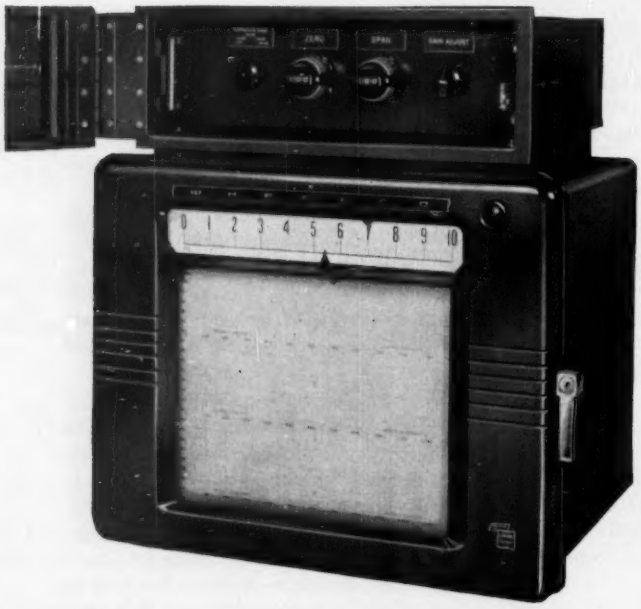
CIRCLE 13 ON READER-SERVICE CARD



NEW ... *through research by Barber-Colman*

Dials read out zero and span adjustment for MV potentials

Digital Dial Recorder/Controller For Span Adjustment or Zero Suppression



The Digital Dial Recorder/Controller saves time and gives you the ranges and flexibility unobtainable in fixed-parameter recorders. You can dial up to 50 MV of zero suppression by 10 MV step knob and calibrated 0-1000 readout counter. OR, you can dial any span from 0-.5 to 0-20 MV with counter calibrated 0-1000. *Changing the span does not affect zero settings; conversely, changing zero settings does not affect span.* A convenient amplifier adjustment knob permits gain settings. Zener diode constant voltage source assures accuracy even at .5 MV span . . . ½ of 1% overall accuracy. Control switches adjust over 100% of full range. Easy-access, swing-away design speeds change of charts, control forms, or components. Any Barber-Colman, Wheelco office will supply full data — contact one now.

BARBER COLMAN

BARBER-COLMAN COMPANY

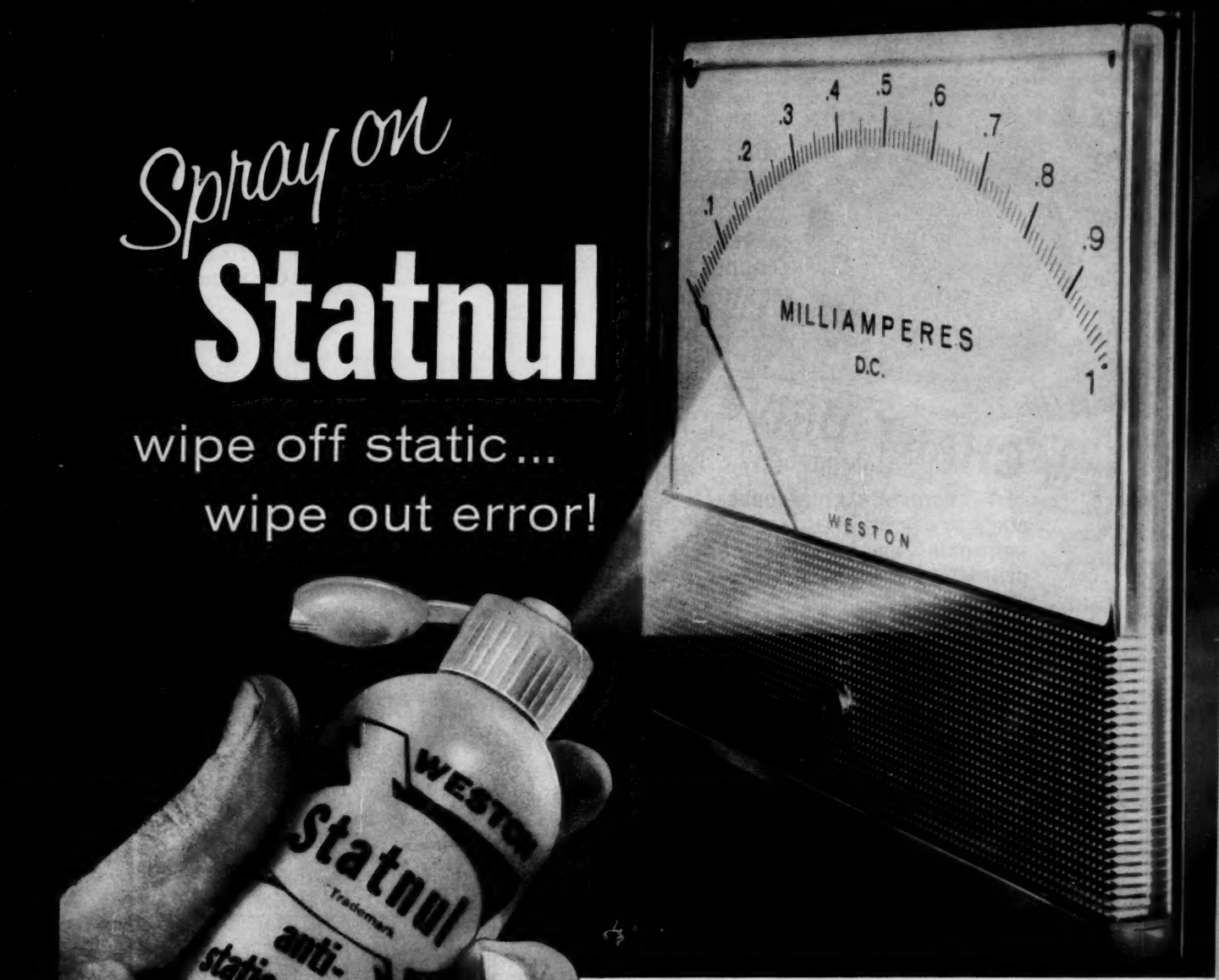
Wheelco Industrial Instruments Division

Dept. U, 1515 Rock Street, Rockford, Illinois, U.S.A.
BARBER-COLMAN of CANADA, Ltd., Dept. U, Toronto & Montreal • Export Agent: Ad. Auriema, Inc., N.Y.

CIRCLE 72 ON READER-SERVICE CARD

Spray on Statnul

wipe off static...
wipe out error!



False readings in test and panel instruments can easily be caused by static electricity . . . especially when meter faces are made of plastic. Now you can protect for months against static error – actually restore original accuracy – with new Weston STATNUL anti-static solution!

It's easy to use: Simply spray or apply with saturated cloth – then wipe. STATNUL leaves an invisible conductive shield which drains away static.

Cleans and polishes with every application . . . wards off abrasive air-borne dust and dirt . . . prevents scratching.

Keep a bottle handy to protect your equipment. Each 3½-oz. container can be used hundreds of times.

Mail coupon today or see your local Weston distributor.

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a product of
DAYSTROM, INCORPORATED
Weston Instruments Division, Newark 12, N. J.

Daystrom, Incorporated
Weston Instruments Div., Dept. IC9
Newark 12, New Jersey

Please send.....bottles of Weston STATNUL ($3.95 each).
Check or money order enclosed ☐ Bill me. Purchase order enclosed ☐

Name.....

Firm.....

Address.....

City.....Zone.....State.....

CIRCLE 73 ON READER-SERVICE CARD

INCREASE RECORDER VERSATILITY

MULTI-SPEED **CHART DRIVE**

FOR STRIP CHART RECORDERS BUILT BY — HONEYWELL — LEEDS & NORTHRUP — BRISTOL — WHEELCO — GENERAL ELECTRIC (EASILY FIELD MOUNTED)

Matches Chart Speed to Test Requirements • Quick dial selection of eight speeds • Improves resolution and readability of plotted curves • Provides greater total chart speed range • Saves chart paper • Saves valuable time.

CHART DRIVES • SPEED REDUCTORS • INSTRUMENT DRIVE SYSTEMS

INSCO COMPANY

DIVISION OF BARRY WRIGHT CORP. BW

GROTON, MASSACHUSETTS

CIRCLE 74 ON READER-SERVICE CARD

Now . . . 7 Sizes of Gould

Solenoid Valves

bear this seal

They're Types Q and Q-1 in all these sizes:
⅜" • ½" • ¾" • 1" • 1¼" • 1½" • 2"

Fully Automatic • Normally Closed • Packless
2-Way • Piston-Pilot Operated • Bronze Body

TYPE Q General purpose for air and water at pressures from 5 to 400 psi; temperatures to 250° F. . . . and steam at pressures to 15 psi; temperatures to 250° F.

TYPE Q-1 For steam at pressures from 5 to 150 psi, and temperatures to 365° F.

Coils of both types are guaranteed unconditionally for a full year

Write for FREE Bulletin on Our Full Line of Solenoid Valves!

TYPICAL USER NET PRICES • F.O.B. FACTORY

SIZE	TYPE Q		TYPE Q-1	
	1 to 5	100 to 499	1 to 5	100 to 499
⅜" or ½"	22.00	19.25	29.10	25.46
¾"	26.00	22.75	33.10	28.96
1"	35.00	30.63	42.10	36.84
1¼"	43.00	37.63	50.10	43.48
1½"	66.00	57.75	73.10	63.96
2"	84.00	73.50	91.10	79.71

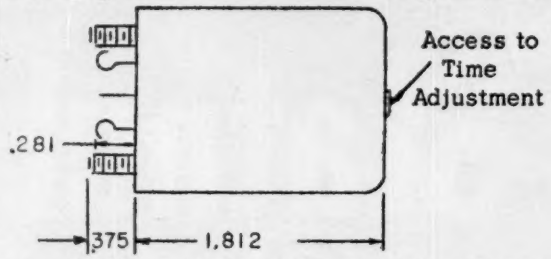
J. D. GOULD CO. • 4707 MASSACHUSETTS AVE. • INDIANAPOLIS 18, IND.

GOULD SOLENOID VALVES — VELVETROL

CIRCLE 75 ON READER-SERVICE CARD

Electronic Interval Timers

Electronic timers have formerly been called "Time Delay Relays." However, this nomenclature has been made obsolete by the advent of solid-state timing devices . . .

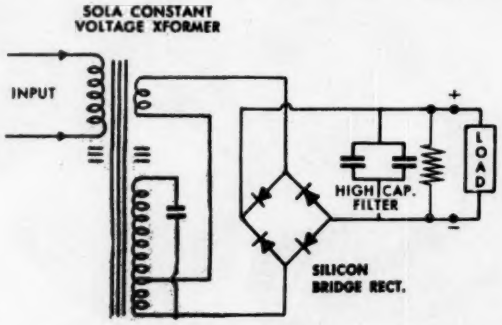


Interval Timers include both the relay and the solid-state types . . . Because Interval Timers can be unintentionally misfired by line-voltage fluctuation and random noise (transients), EPC has deviated from the norm to contribute its . . . Model 200 (Pat Pend.). This is the much sought-after solution to the reliability problem where timers are needed. Time delays from 50 msec to 120 seconds are available . . . (*From new 6-page Engineering Bulletin IT-2, Electronic Products Corp., 4842 Belair Rd., Baltimore 6, Md.*)

FOR THIS LITERATURE CIRCLE 231 ON READER-SERVICE CARD

Constant-Voltage Supplies

Combining Sola Constant Voltage Transformer, silicon power rectifier, and high-capacitance filter . . . (unit) features . . . unusual shorttime or transient overload ca-



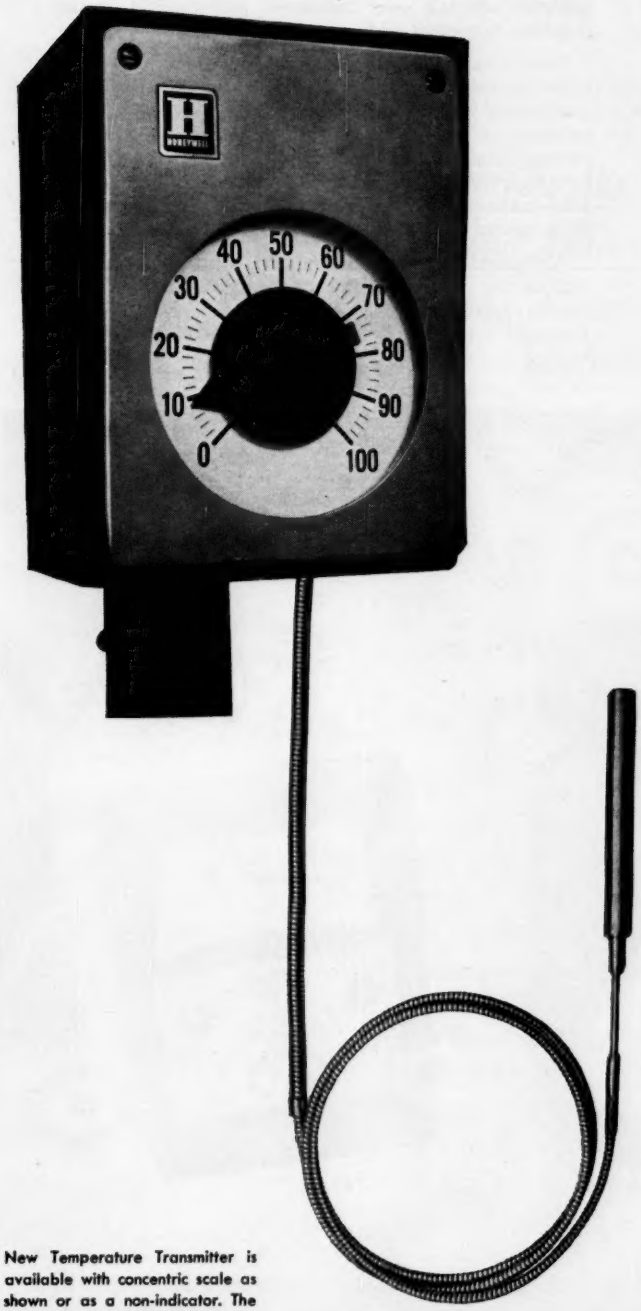
pacity without oversize components; and exceedingly good load regulation over the entire operating range . . . The many unusual advantages of this device depend on a close interrelation of three essential components . . . (a) The transformer, as modified for this special duty, has an output wave shape that is nearly square (form factor approx. 1.05) . . . (b) The constant-voltage transformer provides ac input to the rectifier regulated within ± 1% with line voltage variations of as much as ± 15% . . . (c) The silicon rectifier has the lowest voltage drop of any rectifier within the range of ratings under discussion . . . (d) . . . high-capacitance filters . . . constitute an "energy reservoir" for meeting short transient loads . . . also eliminate the usual filter choke . . . (*From new 8-page Bulletin CV-235A, Sola Electric Co., Div. of Basic Products Corp., 1717 Busse Rd., Elk Grove Village, Ill.*)

FOR THIS LITERATURE CIRCLE 232 ON READER-SERVICE CARD

(*Continued on page* 1628)

NEW TEMPERATURE TRANSMITTER

offers thermal system options with ranges from −125° to 1000°F



New Temperature Transmitter is available with concentric scale as shown or as a non-indicator. The unit transmits with calibrated accuracy of ±0.5% of full scale, and indicates within ±1.0% of full scale.

Completely new, completely flexible, the new Honeywell Temperature Transmitter gives you a choice of either gas or mercury thermal system plus a wide selection of measuring bulb styles. Die-cast aluminum case is 4″ by 7″ by 9″. Concentric scale is 8½″ long.

New built-in rebalancing capsule automatically compensates for changes in ambient temperature. Two-way overload protection covers 100% of span. Maintenance is greatly simplified by modular construction which lets you remove any major component by loosening two screws. All field adjustments are easily accessible, and a self-locking feature prevents upset after calibration adjustments are made.

Transmitter Features: Gas (—125° to 800°F) and mercury (—40° to 1000°F) actuated thermal systems with bulbs for any application. Mount on pipe welded to flow line, or on bracket that clamps on the hex head of the socket. Vibration resistant thermal system means accurate measurement on vibrating flow lines.

For more complete details on the new Temperature Transmitter, call your nearby Honeywell field engineer. Or write for *S630-1*. MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, write Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

CIRCLE 76 ON READER-SERVICE CARD

Here's 0.1° Sensitivity at a Competitive Price!

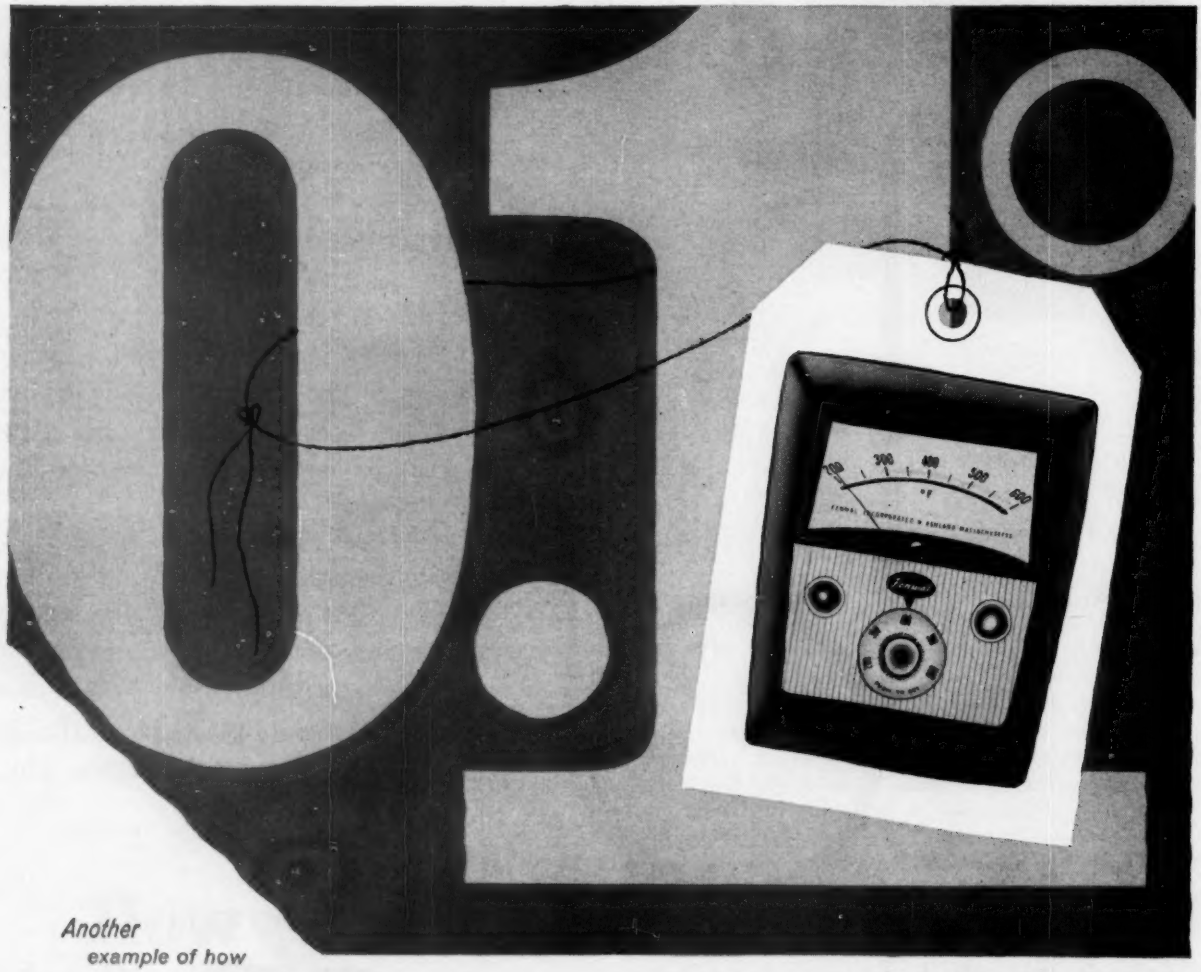
... Fenwal's New "561" Temperature Controller

The new "561" indicating controller responds to temperature changes of 0.1° or less! And is yours at a competitive price! These two features alone make it an instrument you should investigate... but there's more!

You can choose from five standard temperature ranges . . . within the span of −50 to 600°F. Furthermore, scales start and end within *your* ranges, permitting larger graduations, better legibility, easier readout. And control and indication are separate but simultaneous. *Should your indication fail the "561" will continue to control with complete accuracy.*

This precise instrument gives unvarying performance. Its indication and control will not vary with fluctuations of input voltage nor changes in ambient temperature. It offers the option of either ON-OFF or proportional control . . . has 10 AMP/120 VAC relay capacity. Smartly styled to complement modern industrial machines and interiors, *the "561" offers you all these extras at a competitive price.*

A Fenwal engineer will be glad to supply information on the "561", or any other temperature control in Fenwal's broad line. Write Fenwal Incorporated, 369 Pleasant Street, Ashland, Massachusetts.



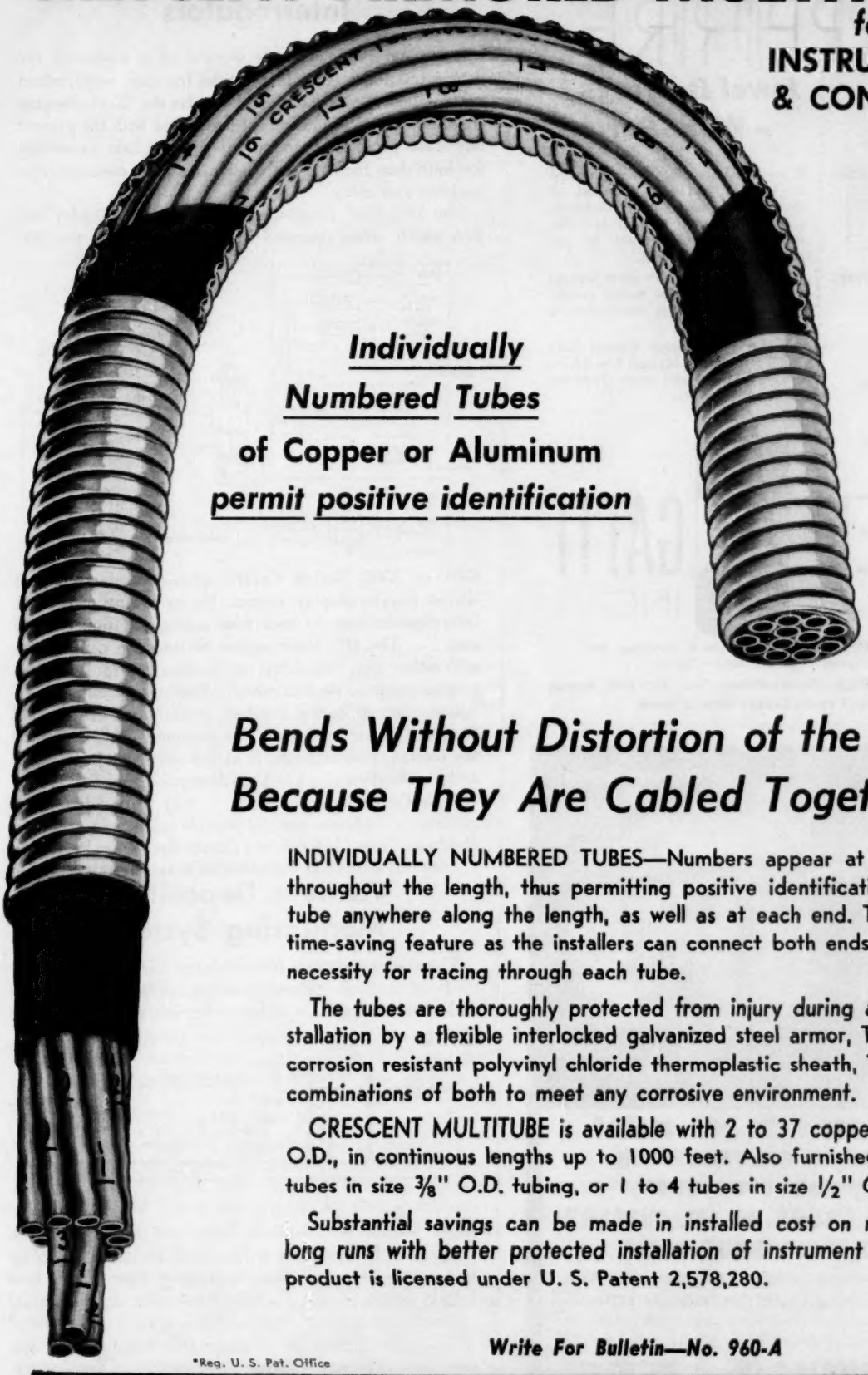
Another example of how

Fenwal CONTROLS TEMPERATURE . . . PRECISELY

CIRCLE 77 ON READER-SERVICE CARD

CRESCENT ARMORED MULTITUBE*

for INSTRUMENTS & CONTROLS



Individually Numbered Tubes

of Copper or Aluminum

permit positive identification

Bends Without Distortion of the Tubes Because They Are Cabled Together

INDIVIDUALLY NUMBERED TUBES—Numbers appear at 2" intervals throughout the length, thus permitting positive identification of every tube anywhere along the length, as well as at each end. This is a real time-saving feature as the installers can connect both ends without the necessity for tracing through each tube.

The tubes are thoroughly protected from injury during and after installation by a flexible interlocked galvanized steel armor, TYPE CA, or corrosion resistant polyvinyl chloride thermoplastic sheath, TYPE CT, or combinations of both to meet any corrosive environment.

CRESCENT MULTITUBE is available with 2 to 37 copper tubes, 1/4" O.D., in continuous lengths up to 1000 feet. Also furnished in 1 to 12 tubes in size 3/8" O.D. tubing, or 1 to 4 tubes in size 1/2" O.D.

Substantial savings can be made in installed cost on moderate to long runs with better protected installation of instrument tubing. This product is licensed under U. S. Patent 2,578,280.

Write For Bulletin—No. 960-A

*Reg. U. S. Pat. Office

CRESCENT INSULATED WIRE & CABLE CO., INC.

TRENTON 5, NEW JERSEY

CIRCLE 78 ON READER-SERVICE CARD

SAPPHIRE

WEAR PARTS

ELECTRICAL INSULATORS

JEWEL BEARING TYPES

Vee

Ring

Endstone

Cup

Orifice

Jewel Bearings - Wear Parts

If you need a surface finish polished to 1 RMS and/or a material of extreme hardness, high dielectric strength, resistance to heat and corrosion, SAPPHIRE could be the answer to your problem.

We design and furnish jewel bearing assemblies, controlled within critical tolerances, for direct installation in your product.

Ask for our 28-page Design Data and Applications Manual No. 5A on Jewel Bearings and other Precision Sapphire Products.

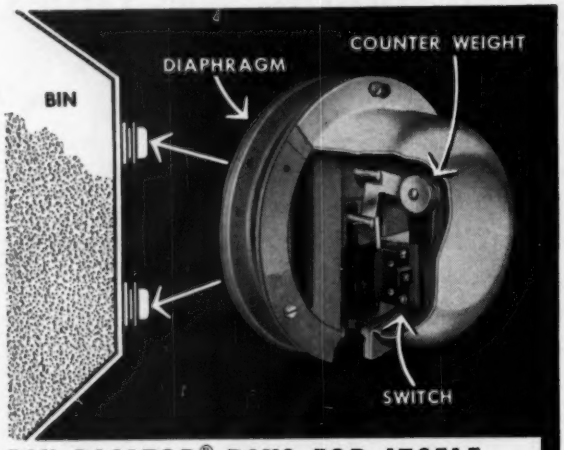
AURELE M GATTI INC.

MAIN OFFICE
532 Tindall Ave.
Trenton, N. J.

WEST COAST REPRESENTATIVE: Harold R. Swanton, Inc.
Los Angeles • San Francisco • Seattle

NEW YORK OFFICE: Charles Kastner, Inc., 580 Fifth Avenue

CIRCLE 79 ON READER-SERVICE CARD



BIN-DICATOR® PAYS FOR ITSELF FIRST TIME IT PREVENTS BIN OVERFLOW, CONVEYOR CLOG, ELEVATOR CHOKE-UP, MACHINERY DAMAGE, REPAIR SHUT-DOWN

If you handle bulk material you probably need Bin-Dicators. The nominal cost of this protection and automatic control makes it the lowest-cost modernization you can buy. Available with Explosion-Proof Switch.

THE BIN-DICATOR CO.
3434 Denver • Detroit 24, Michigan

Write for free copy of catalog BD-15 or call TUxedo 2-3000

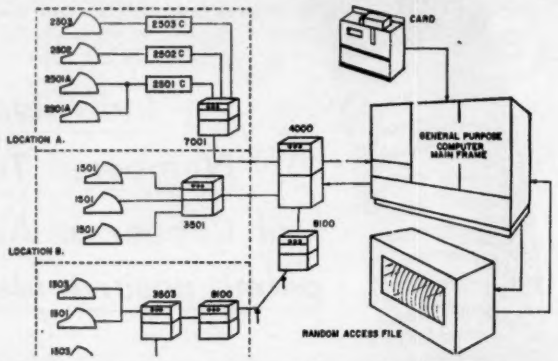
WE SELL DIRECT • PHONE ORDERS COLLECT

CIRCLE 80 ON READER-SERVICE CARD

Interrogators

Interrogators functionally consist of a keyboard for data entry and a cathode ray tube for data vertification and display. They are designed to solve the "man-machine communications" requirement associated with the present day data processing operations and include capability for both data inquiry and display, and for message composition and entry . . .

The IPC 1501 Interrogator is an inquiry-display station which, when operated in conjunction with the IPC

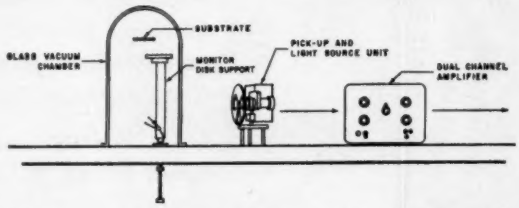


3501 or 3503 Station Control provides an equipment shared inquiry-display system. Up to twenty IPC 1501 Interrogators may be used with a single Station Control unit . . . The IPC Interrogator Stations, in conjunction with either their individual or common control units, are general purpose devices which allow convenient and efficient communication between a computer or file and the point of use operators. The sequence of operation of the Interrogator Stations, is as follows: (1) Data Entry and Verification . . . (2) Data Reception and Display. . . (3) Re-Transmission of Data . . . (4) Data Add-On Facilities . . . (*From new 32-page brochure, Information Products Corp., 156 6th St., Cambridge, Mass.*)

FOR THIS LITERATURE CIRCLE 233 ON READER-SERVICE CARD

Vacuum Deposition Monitoring System

The system monitors film thickness to 0.25 percent . . . up to 20 coatings without breaking vacuum . . . metal or dielectric coatings for either reflection or transmission.



Light source is Tungsten lamp and projection lens, chopped at 90 cps, by a synchronous motor . . . Pick-up is focusing objective lens, six-position filter wheel, lead sulfide detector cell . . . Amplifier-power supply is dual channel solid state . . . designed to operate a conventional dc 10-millivolt recorder or meter (not supplied with system) . . . (*From new 2-page bulletin, Optics Technology, Inc., 248 Harbor Blvd., Belmont, Calif.*)

FOR THIS LITERATURE CIRCLE 234 ON READER-SERVICE CARD

(*Continued on page* 1630)

New
Improved
Lino-Writ 5
Use it as
a direct
writing paper
or develop it
with new
processing kit

Lino-Writ 5, proved the most dependable direct writing photo-recording paper you can use, now adds a new bonus: you can use it as a completely dry process paper, or you can process it, for permanent trace results, with Du Pont's new Direct Writing Paper Processing Chemicals Kit.

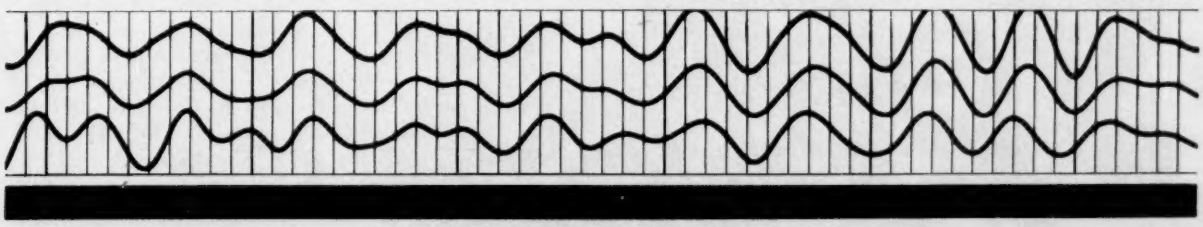
Improved Lino-Writ 5 is still outstanding for dry-processed image stability and requires no stabilizing treatment for handling under normal room light conditions. Records may now be processed for greater permanence, for making reproductions with diazo equipment or for handling for prolonged periods under intense lighting.

Improved Lino-Writ 5: up to 100,000 ips... easy-to-read traces ... and now, use it either dry or wet process.

DU PONT

BETTER THINGS FOR BETTER LIVING ... *THROUGH CHEMISTRY*

E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Del. In Canada: Du Pont of Canada Ltd., Toronto



CIRCLE 81 ON READER-SERVICE CARD

CUT COSTLY INSTRUMENT MAINTENANCE

with

Clean Dry Oil-Free Compressed Air

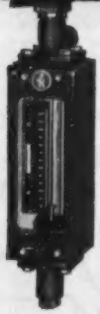
An Adams aftercooler and cyclone separator installed in your instrument air supply cools the discharge air to within 2° of cooling water temperature. Over 90% of the moisture and virtually all of the oil are condensed. The exclusive Adams cyclone separator then removes the condensed liquid oil and water and other foreign material with uniform high efficiency — over the entire operating range. This air is entirely suitable for air motor and most control applications. When bone dry air is needed, the chemical drier load is then limited only to polishing action, since the bulk of the moisture will have been removed by lower cost condensation. Why not review the cost cutting advantages of an Adams aftercooler-separator combination? Ask today for your free copy of Bulletin 715. R. P. Adams Co., Inc., 265 East Park Drive, Buffalo 17, New York.

ADAMS *QUALITY COMES THROUGH*

CIRCLE 82 ON READER-SERVICE CARD

NEW/IMPROVED

PNEUMATIC TRANSMITTING ROTAMETER



New "position-balance" type Transmitter . . . air-signals fluid rates of flow to remote recorders, controllers . . . incorporates *exclusive* calibration adjustments (no cams) and drag-eliminating magnet design . . . scale suitable for any calibration . . . offers other features of real value all detailed in new Bulletin 18N. Write for a copy.

Schutte and Koerting COMPANY

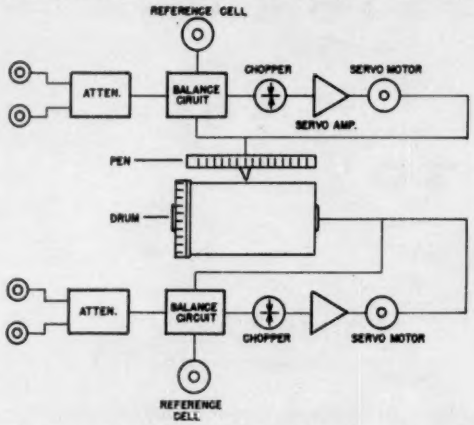
INSTRUMENT DIVISION

2225 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

CIRCLE 83 ON READER-SERVICE CARD

X-Y Recorders

The Model 1 Autograf Recorder is a portable, self-contained instrument for producing permanent records of the relationship between a dependent and independent variable when linearly proportional DC voltages representing the original information are applied to the respective axis inputs. These applied signals control independent servo drives one of which rotates a drum type platen in the X direction and the other moves a pen in the Y direction.

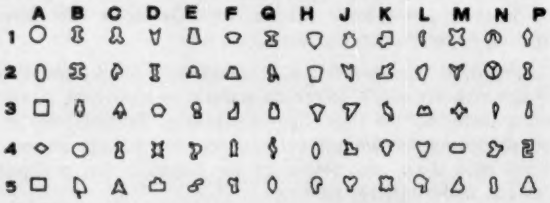


The relative motion of the drum and pen traces a cartesian coordinate curve on standard graph paper which clamps on the drum . . . The Model 2D Autograf 11″ x 17″ X-Y Recorder, basically designed to draw cartesian corrdinate curves automatically from two related sources of DC electrical information, will also plot one variable against time, accept AC input data on either or both axes, and operate directly from a variety of Autograf accessories including punched tape and card translators, keyboards, and logarithmic converters. It can be supplied with a built-in magnetic curve follower . . . or with the new photo-electric Type F-2 Line Follower which reproduces original information plotted with pigment type black ink . . . (*From 44-page Catalog K, F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 235 ON READER-SERVICE CARD

Inspection Stamps

Unlike ordinary stamps, marking devices made from Mecco Safety Steel will not mushroom or spall—thereby assuring safety from chips and splinters . . .



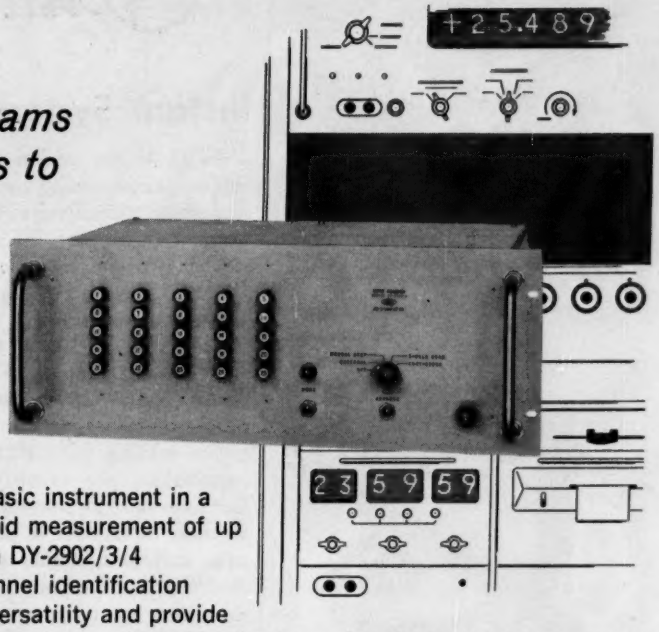
Code symbols shown as well as special designs as required are available in both styles of stamps. Used by workmen and inspectors, they fix responsibility for their work. They also serve widely for code dating, coding of specifications, indicating contents of containers and other service . . . (*From new 48-page Catalog 300, M. E. Cunningham Co., 1025 Chateau St., Pittsburgh 33, Pa.*)

FOR THIS LITERATURE CIRCLE 236 ON READER-SERVICE CARD

(*Continued on page* 1634)

EFFICIENT AUTOMATIC MULTI-POINT MEASUREMENT

New Input Scanner programs up to 100 data points to one measuring device



With off-the-shelf Dymec instrumentation it's simple to measure pressure, flow, temperature, velocity, volume—any parameter that can be converted to or related to a voltage, frequency, time interval or period, resistance or current.

Using the DY-2901 Input Scanner as the basic instrument in a system, for example, you can program rapid measurement of up to 25 points—or up to 100 inputs with the DY-2902/3/4 slave scanners. Built-in programming, channel identification and latch-lock input connectors increase versatility and provide money-saving utility. Channels to be measured are selected by front-panel buttons and programmed by an internal pin board which lets you select function and range of the measuring equipment.

With the DY-2901, you can make more effective use of other Dymec instruments such as the DY-2401 Integrating Digital Voltmeter, the DY-2410 Multi-Converter, and the DY-2540 Coupler. Application Note 15 describes complete Dymec Systems capabilities.

Here are some of the inputs you can measure with these systems:

- dc voltage, from a few mv to 1,000 v
- ac voltage, from a fraction of a volt to 750 v rms, 20 cps to 100 KC or more
- frequency, dc to 10 MC or more
- time interval or period, from less than 1 nanosecond to 100 days
- resistance, fractions of an ohm to 100 megohms or more
- current, from 10^{-9} amps to 10 amps or more

And here are some of the features your Dymec system can provide:

- Scaling: Multiplying factors can be pre-set to provide digital readings in desired measuring units (psi, gpm, rpm, etc.)
- Ranging: Measuring equipment can be automatically programmed to desired range for each channel
- Normalizing: Separate multiplying factor can be supplied for each channel to relate all measurements to a par value
- Scale Expansion: Zero offset provides high measurement resolution on each range
- Sequence: Individual channels can be omitted from any measurement cycle

Call your Dymec/Hewlett-Packard representative today or call direct for specifications on the DY-2901 Input Scanner ($1,950), DY-2401 Digital Voltmeter ($3,750), DY-2410 Multi-Converter ($1,975), DY-2540 Coupler (typically $1,200 to $2,400), or other Dymec instruments for versatile systems application.

DYMEC

A Division of Hewlett-Packard Company

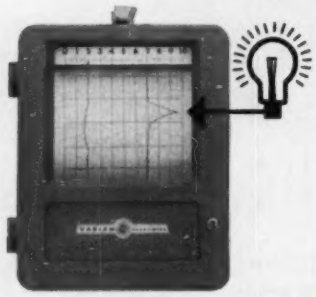
dy

Dept. S-9, 395 Page Mill Road, Palo Alto, California • DAvenport 6-1755 (Area Code 415)

TWX-117-U

CIRCLE 84 ON READER-SERVICE CARD

VARIAN
Potentiometer
RECORDERS
Offer exceptional
versatility because...



THERE ARE ACCESSORIES FOR

ALARM/CONTROL

Alarm and control switches, and retransmitting slide wires, add a valuable dimension of simple control to the already-versatile two-channel G-22. With these optional accessories they can work unattended to control two variables within the 1% accuracy of the recorder, while making a permanent record of what has happened.

1% accuracy, spans from 10 mv to 500 v, 1 second full-scale balance time, two chart speeds standard, four optional (3/4"/hr. to 16"/min.), full scale zero adjust, event markers and other options. Portable and rack-mounted models available from $1,075. Write Instrument Division:

VARIAN associates
PALO ALTO 27, CALIFORNIA
CIRCLE 85 ON READER-SERVICE CARD

ICS PANHANDLE PETE

Instant Systems

As all 45,000 avid readers of this column know (how come none of you wrote while Panhandle Pete was on vacation?—ED), WESCO! has installed a new solid-state high-speed Digital Computer to handle all its accounting, engineering, research, office, inventory, and bookkeeping functions. In order to keep this wonderful ($457,962.01/month) machine busy at optimum efficiency (that means making $457,962.01 worth of calculations per month), WESCO! had to expand its research laboratory, increase its number of products, hire new staff and double its salesmen. WESCO! is proud and pleased to report that its computer will soon be breaking even (or else the local bank).

Like everything else, however, the solution of one problem has produced others—and here comes our Genial Sales Manager Waldo Klappsaddle with another problem.

"Why so glum, WALDO?" I ask, "The Computer is finally making money for us, isn't it"?

"Yes, but the Computer has just figured out that while it is making money the company is losing it," replies Waldo, no longer genial at all.

"Why is that"? I ask.

"Simply because the new research men, the new production staff, and the new salesmen we hired in order to make the Computer economic are producing so many new products that we have to build a new warehouse and production plant, and we don't have enough money for that and the Computer rental at the same time," replies Waldo.

"For heaven sakes, Waldo," I reply, "you have no faith in modern Computers at all. By this time everybody knows that the Computer can solve that little problem for us in no time at all—or at most maybe 7.63 microseconds. This is a conventional problem in optimization, efficient utilization of resources and proper allocation of functions and funds. Why those subjects are covered in the first 20 pages of the manual that came with the Computer. Just give the problem to the Computer—it will solve it."

"You have indeed become a solver of problems since you became a systems engineer instead of instrument peddler," says Waldo as he dashed into the new Computer building, shouting for all the programmers to drop their digits and hop on the new problem.

Exactly 7.63 microseconds later, out comes Waldo, again his old genial self, proudly waving a sheaf of papers about 8" thick, typed out on our high-speed (642,471,362 words per second) printer.

"Well, what did the Computer say we should do?" I ask.

"Just a minute," says Waldo, "The first part of the problem here analyzes our function allocations; the second 20 pages cover our decision making organization and structure; the next 50 pages analyze our system-determined factors; the next 40 pages covers availability and probability relationships; the next 100 pages analyzes our relative location factors; about 20 pages are devoted to maintenance policies; 10 pages to personnel factors, and the last page is the conclusion. Which would you like to see"? asks Waldo,

"Just the conclusion," I reply pleasantly, "Just the conclusion."

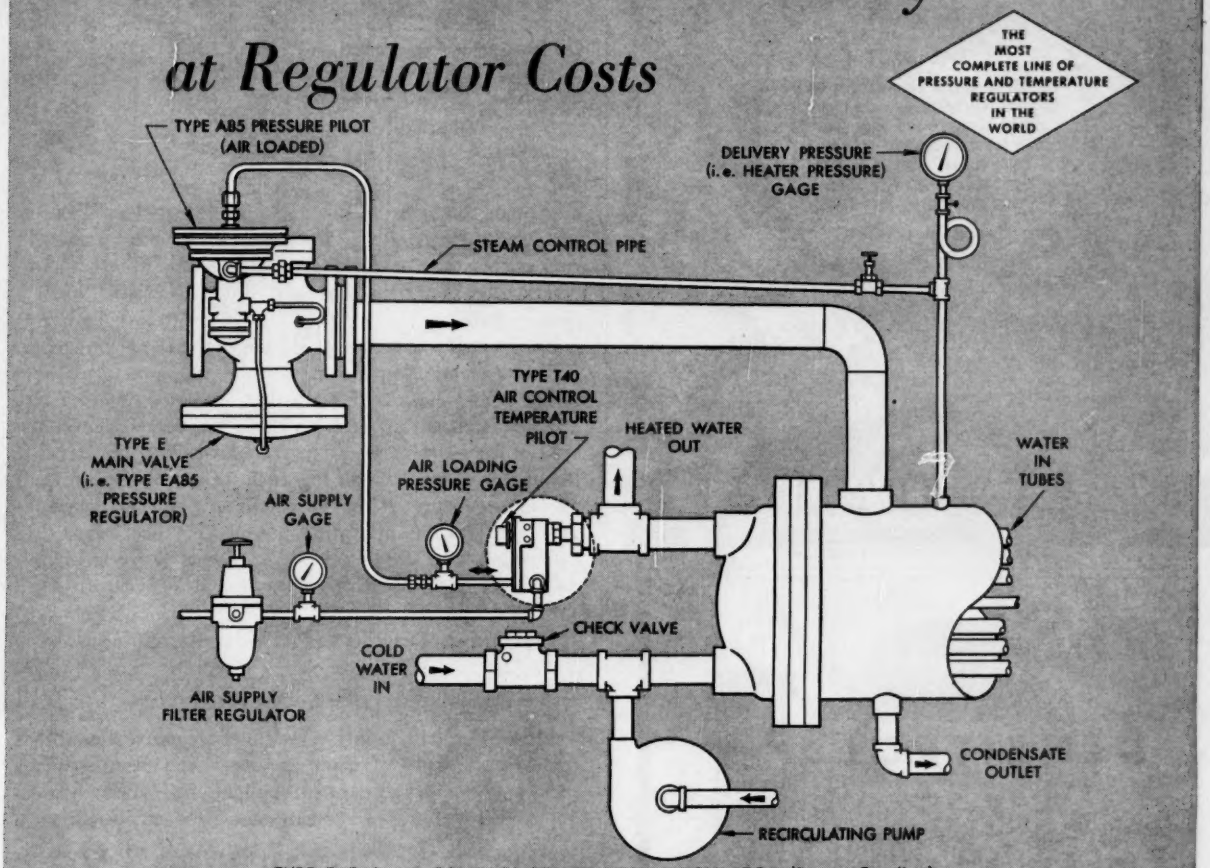
Well, here it is," replies Waldo, as he reads from the Computer-typed material:

"WESCO! can't reduce any personnel because then its computer becomes uneconomic—so WESCO! must reduce its products. The answer is to reduce the products to the bare number of essential products. This will immediately reduce the WESCO! inventory from its present number of 462 items, 3642 subsystems and 4764 systems to those three items out of which all electronic systems are made —(1) resistance, (2) capacitance, (3) inductance. With your staff and these three products, WESCO! can now offer DO-IT-YOURSELF INSTANT SYSTEMS. END OF PROBLEM.

Panhandle Pete

CONTROL TIPS:

New Spence Temperature Control System with Cascade Control Accuracy at Regulator Costs


THE MOST COMPLETE LINE OF PRESSURE AND TEMPERATURE REGULATORS IN THE WORLD
TYPE AB5 PRESSURE PILOT (AIR LOADED)
DELIVERY PRESSURE (i.e. HEATER PRESSURE) GAGE
STEAM CONTROL PIPE
TYPE T40 AIR CONTROL TEMPERATURE PILOT
HEATED WATER OUT
TYPE E MAIN VALVE (i.e. TYPE EA85 PRESSURE REGULATOR)
AIR LOADING PRESSURE GAGE
AIR SUPPLY GAGE
WATER IN TUBES
CHECK VALVE
COLD WATER IN
AIR SUPPLY FILTER REGULATOR
CONDENSATE OUTLET
RECIRCULATING PUMP

TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden 1, New York SE-1488A

CIRCLE 86 ON READER-SERVICE CARD

PHILADELPHIA
THERMAL CONTROLS AND
THERMOMETERS
Specify!
THE BEST!
A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.
SEND FOR CATALOG
110
Since 1905
PHILADELPHIA THERMOMETER CO.
4401 N. Sixth St. • Philadelphia 40, Pa.

CIRCLE 87 ON READER-SERVICE CARD

NEW! PRINCO

DENSITROL W-756

for direct and continuous indication of specific gravity in process liquids

This rugged, extremely accurate, dependable DENSITROL offers time and money saving advantages:

1. Immediate availability from stock—in custom ranges for .05 or .10 span, in any range between .65 and 1.40 limits.
2. Exceptional corrosion resistance—wetted surfaces are Pyrex, Tantalum and Teflon.
3. Accurate to ± 1%.
4. Extremely rugged—body is Double-Tough Pyrex.
5. Non-electrical—no explosion hazard.
6. Single adjustment corrects for temperature—density effects.
7. Continuous, immediate in-line indication.

Send for Bulletin W-9, or write, wire or phone for further information.

PRINCO

PRECISION THERMOMETER AND INSTRUMENT CO.

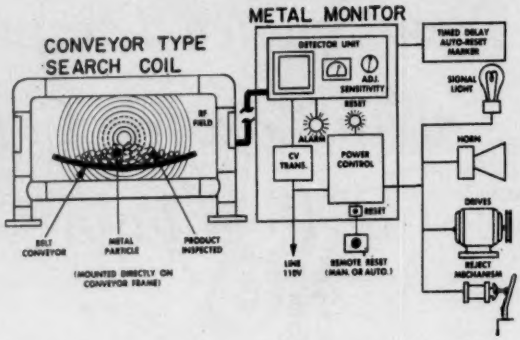
PHONE: LOcust 3-6671

1434 Brandywine Street, Phila. 30, Pa.

CIRCLE 88 ON READER-SERVICE CARD

RF Metal Detector

RF (radio frequency) metal detectors are used for locating all metals and alloys, whether they occur as large or small pieces of steel, manganese, aluminum, brass or



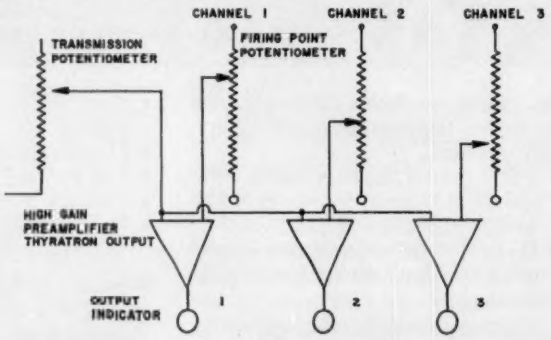
any other metal or metal alloy. Their usual application involves indicating the presence of "tramp" metal in rubber, plastics, food, drugs, minerals or any other nonconducting materials that will not affect a radio frequency field . . .

The primary components of the Metabloc are a search coil and a main control unit. The search coil forms part of the tuned circuit of a Hartley oscillator. When energized, this circuit generates a radio frequency field in the area of the search coil. Energy is absorbed when a metallic object moves through this field, causing an upset voltage to be generated by the oscillator. This voltage triggers a thyratron, activating a sensitive relay which, in turn, controls a power relay . . . (*From new 8-page Bulletin 203, Morehouse Machine Co., 1742 Sixth Ave., York, Pa.*)

FOR THIS LITERATURE CIRCLE 237 ON READER-SERVICE CARD

Limit Control

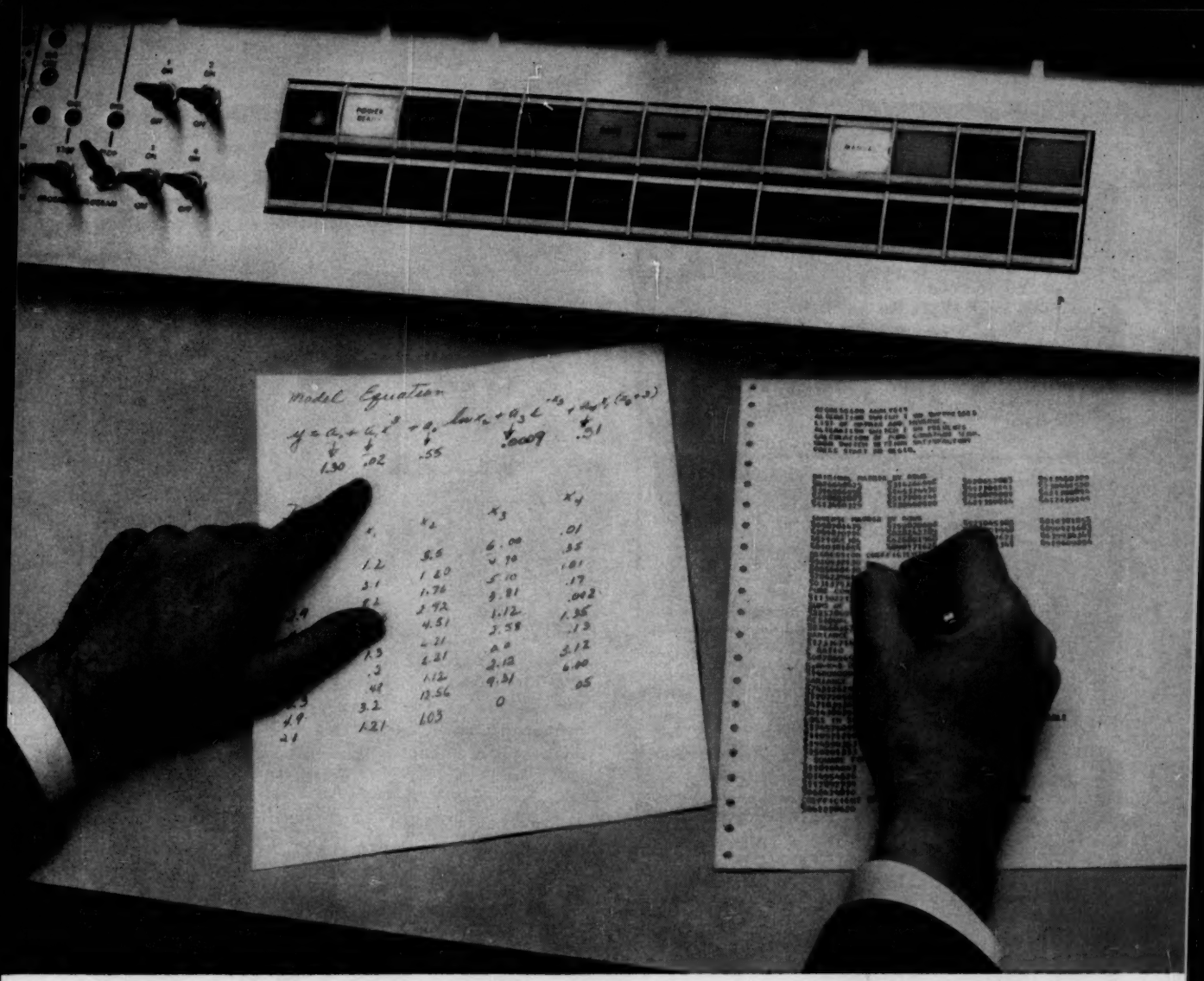
Elasco-Cam is a highly versatile electronic device which replaces an array of cams and precision microswitches in measurement and control applications. Physically, the apparatus includes a transmission element, such as a



simple resistance potentiometer, and an electronic box which generally has two or more separate channels. As the potentiometer shaft is rotated, the separate channels are "triggered" at precisely repeatable points. The "triggering points" are easily adjustable by setting individual channel potentiometers . . . (*From News Release, Elasco, Roxbury, Mass.*)

FOR THIS LITERATURE CIRCLE 238 ON READER-SERVICE CARD

(*Continued on page* 1636)



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The new Regression Analysis program lets you handle expressions containing up to *24 variables*. If you have the even more complicated task of handling many dependent variables, the program will generate regression coefficients with a maximum number of dependent variables not exceeding one-half the number of independent variables.

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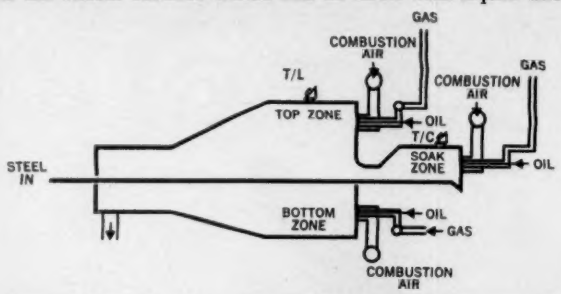
The heat transfer requirements of each mill heating process determine the type of fuel necessary. One of the most readily adapted processes to by-product fuel firing is the reheat furnace which can be fired with liquid and



gaseous fuels, singly or in combinations. The amount of surplus fuel available to the reheating furnaces will, of course, vary widely, and at times very rapidly meaning that for economical and efficient operation some type of control must be used to maintain the heat input rate at the predetermined value. Obviously then, the first requirement is a suitable make-up fuel, usually fuel oil, to make up the difference in furnace fuel demand and available by-product fuel.

Operating problems are multipled because combustion air must also be supplied in the correct proportions for combustion with several different fuels to maintain the proper furnace atmosphere . . . The electronic fuel computing system is readily adjustable for heating value of fuels, fuel flow rates, sequence of fuels, and fuel air ratio changes . . . (*From 24-page Folio* 122, *GPE Controls, Inc., 240 E. Ontario St., Chicago* 11, *Ill.*)

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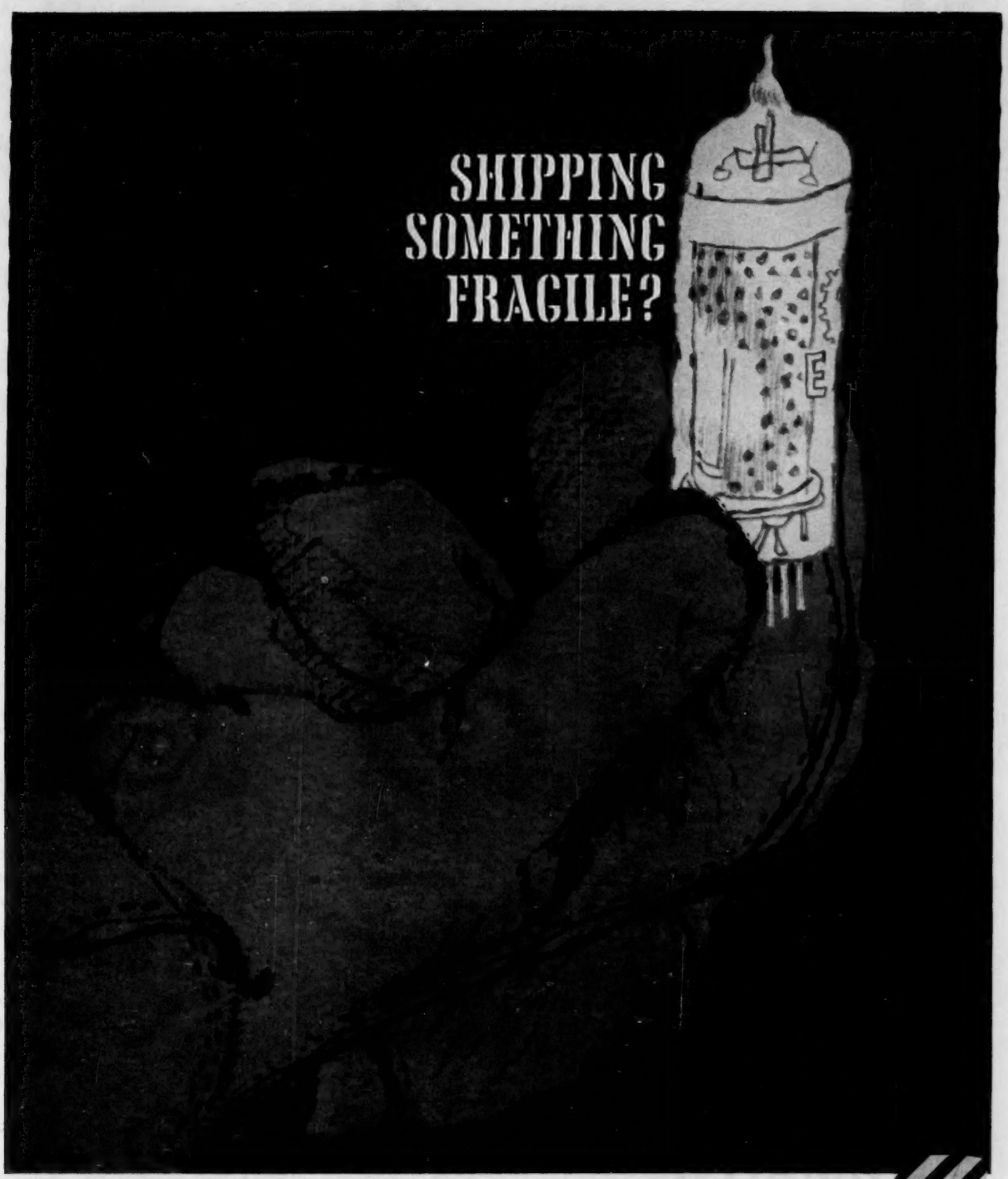

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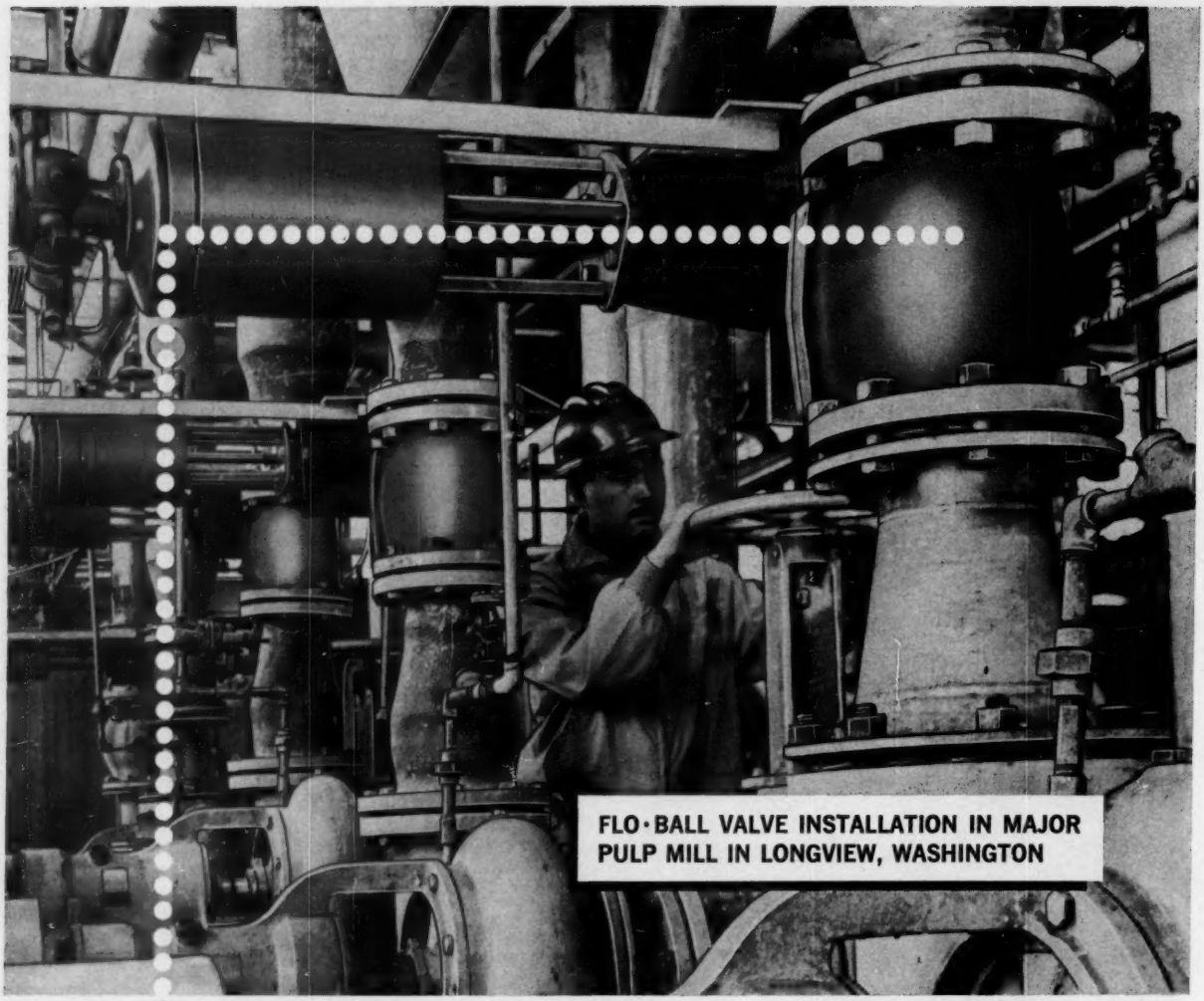

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EDITORIAL

LEASE OR PURCHASE?

ROBERT SHERIDAN
President, Nationwide Leasing Company

EQUIPMENT LEASING has developed into an important new way for manufacturers to acquire new equipment. Production and office equipment leased by American industry in 1960 totalled $530 million. Of this, a large proportion was invested in instruments and control systems. (The leasing of computers is not included in this data because charges are based on yearly rentals, not long-term leases, and also because the costs of service are included in the rentals.)

Through leasing, a company is supplied with additional capital in the form of machinery and equipment, while its own cash is left free to work in the business. More working capital, plus newest equipment, plus certain tax-timing advantages add up to additional growth plus additional profits. The growing realization that equipment leasing offers such benefits goes far to explain the boom in this field.

Smaller companies find that leasing tends to help smaller firms compete with larger ones.

Businessmen lease equipment for one of several reasons:

1. **Long-term financing is obtained without impairing a company's short-term credit position.**
2. **The cost of equipment is paid out of earnings made during its use.**
3. **Leasing charges are legitimately deductible as operating expenses.**
4. **Long-term financing is obtained through leasing without diluting the equity of owners or stockholders, or interference with management.**
5. **Companies can obtain through leasing the precise amount of financing needed (in the form of equipment), rather than larger round sums.**
6. **Leasing protects a firm against possible early obsolescence of equipment.**

Leasing vs Cash Purchase

One client is a soundly-run firm with sufficient liquid capital on hand to take $60,000 out of its working funds to buy this amount of equipment outright. The company is also a profitable one with its sales volume expanding yearly. Its rate of profit on *working capital before taxes* is 31%. This is under the national average for all industry, which is 37%. Its after-tax profit rate on working capital thus was about 15%. (This is why this company was anxious to keep its working capital intact, so as to be able to earn the greatest potential profit.)

Terms for *cash purchase* were cash, net 30 days; depreciation method used by the firm is sum-of-the-digits. The lease plan covered a 10-year period, which is the average of the estimated useful life of the different pieces of equipment. It was broken into a three-year original lease term and seven one-year renewals. In the three-year original lease term the company paid the original price of the equipment ($60,000) plus a small leasing charge. The seven one-year renewals were at the rate of 5% of the original purchase price of the equipment of $3,000 a year.

The company's accountant then undertook an analysis to determine whether the greater total cash outlay under the lease plan (over the 10-year period) was offset by the profits earned on the working capital left free to work in the business.*

Starting point of the analysis was the larger cash flow generated by the working capital retained in the business because of leasing. In the first year this amounted to about $42,000. This cash excess recurred in smaller amounts in succeeding years, and in the later years of the lease was replaced with a cash deficit.

Projecting these figures over the 10-year period, the company calculated the net profits it would earn by putting to work the additional working capital made available to it through leasing. The outcome was that by leasing the equipment, instead of purchasing it for cash, the company would find itself about $30,000 ahead in cumulative net profits after taxes at the end of the 10-year period of the lease. This is 50% of the original price of the equipment.

This is not mathematical sleight-of-hand. It reflects a simple fact: when any company takes any sum out

*An objective study, including voluminous tables, covering this and other aspects of equipment leasing, has been published by the Foundation for Management Research. It is entitled: "The Pros and Cons of Leasing." Single free copies are available to executives by writing to the Foundation at 121 West Adams Street, Chicago 3, Ill.

of its working capital and freezes it in equipment, the company gives up exactly the amount of profit the frozen capital would earn if used in the business. *Profits are earned by the use of assets, not the ownership of them.*

Leasing vs Installment Purchase

Cash purchase is not as common among medium and smaller manufacturers as among larger ones. More usual is purchase on conditional sales contract. This also was open to our client. Terms were fairly typical: 25% down payment, with three years to pay the balance, with a financing rate of 6% per year on the original $45,000 balance.

The same kind of financial projection was made as in considering cash purchase vs leasing. Conclusion: if the equipment were leased, at the end of the 10-year period the company would be approximately $19,000 ahead in greater cumulative net profits than if it bought the equipment on conditional sales contract. This $19,000 represents 31% of the original price of the equipment.

Leasing vs Bank-Financed Purchase

A third alternative available is purchase through a bank loan.

A bank will lend only 75% of the value of the equipment—assuming that the equipment is a common variety of saleable machinery. Banks do not like to lend money on special equipment which has only a limited resale market (Nationwide Leasing Company will lease any type of tailor-made equipment). Also, banks cast a jaundiced eye on applications for long-term (more than one-year) loans to acquire equipment. Only a small portion of a firm's borrowing from its banks can consist of long-term equipment loans. Also the rate on a 36-month chattel mortgage on equipment is higher than the rate as a 90-day note.

Our client was in a position to obtain bank financing—25% had to come out of his working capital; finance rate was 5% of the original balance for three years. Using the same calculations, the company found that at the end of 10 years it would be about $17,000 ahead in greater cumulative net profits after taxes if it leased the equipment instead of buying through bank financing.

In summary, our client found that by leasing his $60,000 worth of equipment he would be about $30,000 ahead in net profits as against outright cash purchase; about $19,000 ahead in net profits over instalment purchase; and about $17,000 ahead in net profits over purchase through bank financing.

There is one disadvantage of leasing—at the end of the lease term (or any other time) a company does not own the equipment. However, not owning the equipment at the end of the lease term is a disadvantage only under one possibility—if the used equipment at the end of the lease is worth more than the additional profits earned as a result of leasing.

To take the example discussed, it is not likely that at the end of 10 years the equipment would be worth 59%, 31% or 28% of the original cost.

There are three types of companies which will *not* find leasing advantageous:

1. The company which has all the working capital it needs, and which does not require any newer equipment.
2. Companies which earn less than 10% on *working capital* (not total investment) *before taxes*, should not lease. 10% on working capital *before taxes* is less than 4.8% on working capital *after taxes*.
3. No leasing company will lease equipment to any company if the value of the equipment is greater than about 50% of the company's net worth.

Within these limits, leasing has provided a golden opportunity for many firms to spurt ahead in sales and profits.

Editor's note:

Some financial experts believe that the three basic reasons for leasing equipment are:

1. Insufficient working capital.

2. Protection against obsolescence by stipulating in the lease that new or more efficient equipment will be substituted for old as soon as available.

3. Increased flexibility for expansion or contraction; protecting against instability in the economy. If times get better the firm has cash to expand; if times get worse, the lease can be terminated at its three-year expiration.

The case history cited in this editorial is based on a manufacturer who apparently had an assured and stable market for as much of his product as he could produce.

WESCON—1961

In the perverse and welcome cool of San Francisco at its August best, the 1961 WESCON show made its annual assault on the senses of an estimated 35,000 attendants. Over 850 exhibitors manned 1170 booths—up from 940 last year. The 42 technical sessions featured some 120 papers in such fields as radio astronomy, electro-optical components, reliability and nanosecond techniques.

Instrumentation and Test included many sizes and varieties of counters. Computer Measurements showed production models of its solid-state 10-Mc and 100-Mc Counters, while Erie Pacific showed for the first time its new 20-Mc Counters, requiring only 3½" in standard 19" racks.

Tektronix unveiled its 567 Readout System and the x 661 0.35-Nanosecond-Risetime Sampling Oscilloscope. Electro Instruments showed off a monitor oscilloscope bay featuring miniature oscilloscopes, and a solid-state five-digit digital voltmeter. Cubic Corporation submerged its VR-2100 digital voltmeter/ratiometer and showed for the first time its new medium-speed data acquisition system. The 100-point data logging system samples 100 channels in one minute.

Bourns showed both unbonded strain-gage pressure transducers and a variable reluctance DC-DC pressure transducer. Eldorado Electronics showed a two-nano-

(*Continued on page* 1661)

H. R. 7035 In the Senate of The United States June 14, 1961 Referred to the Committee on Appropriations and ordered to be printed

INTENDED to be proposed by Mr. Humphrey to the bill (H.R. 7035, 87th Congress, 1st Session) making appropriations for the Departments of Labor, and Health, Education, and Welfare. and related agencies, for the fiscal year ending June 30, 1962, and for other purposes.

Departments of Labor, and Health, Education and Welfare, and Related Agencies Appropriation Bill, 1962—Amendments

MR. HUMPHREY. I submit, for appropriate reference, a series of medical and health-related amendments to H.R. 7035. This is the appropriation bill for the 1962 fiscal year for the Department of Health, Education, and Welfare.

These particular phases covered today are seven in number; they are contained in four amendments. The seven objectives which I respectfully submit to the Appropriations Subcommittee are:

1. Establishment of two regional rehabilitation centers;

2. Establishment of two regional instrumentation centers;

3. Authorization of foreign currencies for international research, at not less than the level proposed by the administration;

4. Expanded information research to unblock the choked arteries of medical communications;

5. An inexpensive study of the multi-billion-dollar costs of disease and disability to society;

6. A comparable study of an international medical audio-visual exchange program; and

7. A consultative study of coordinated Federal-State-local programs for the mentally retarded.

Text of amendment

On page 21, line 4, strike out "$19,250,000" and insert in lieu thereof "$21,250,000 of which $1,500,000 shall be used only for the establishment of each of two original institutes of rehabilitation."

On page 30, line 9, strike out "$119,275,000" and insert "$122,275,000, of which $1,500,000 shall be used only for the establishment of each of two regional centers for biomedical instrumentation for the purpose of research in medical electronic and other instrumentation."

Reasons for amendment

House Report No. 392 makes a strong case for moving ahead rapidly in instrumentation research. It points out (p. 726ff) in a memorandum by Prof. William G. Kubicek, Ph. D., Department of Physical Medicine and Rehabilitation, University of Minnesota, Minneapolis, this striking example of need and opportunity:

"In spite of the many millions of dollars expended for heart research and the efforts by scientists in virtually all countries of the world to improve the treatment of heart disease, there is no method available today to provide the physician with a continuous record of cardiac output. This would provide a great advance in the treatment of heart disease. Currently available electronic instruments can provide continuous records of pulse rate and blood pressure. In evaluating the cardiac patient for ability to return to his job or to his previous environment the physician needs to know the response of the heart to exercise. The ability of the heart to pump additional amounts of blood during exercise is the one vital measurement that the average physician cannot make today. The inability of the physician to accurately judge the ability of the heart to pump blood under exercise conditions constitutes a hazard to all cardiac patients."

Studies made by the Senate Government Operations Subcommittee on Reorganization and International Organizations show these facts:

(a) In 1960, the U.S. Government was spending $2 billion for military electronics research, development, testing, and evaluation.

(b) That same year, the U.S. Government was spending only $2 million for medical electronic research.

Obviously, there is an enormous disparity between the two figures. Obviously, too, there is tremendous opportunity to capitalize in medical electronics on many of the phenomenal findings and instruments developed in the $2 billion worth of military-space electronics research.

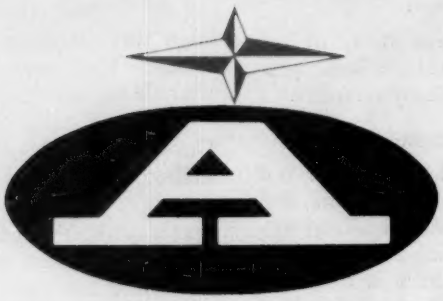
For example, the microminiaturized instruments which telemeter physiological data from outer space are already beginning to find their way into clinical use. But clinical application is developing only at a rather modest pace.

The pace can be accelerated if more resources are made available for medical instrumentation research and development.

From a fiscal standpoint alone, it is widely recognized that tremendous increases in medical efficiency and considerable manpower savings will become possible through monitoring and diagnosis of patients by electronic means—under appropriate medical supervision and evaluation, of course.

Establishment of the two regional centers will make feasible intrauniversity, interdisciplinary cooperation which is not now feasible. Departments of electrical engineering will be brought into closer teamwork with medical colleges and teaching hospitals. Physicists, biophysicists, engineers, bionicists, M.D.'s, chemists, biochemists and many other specialized experts will be enabled to work together at the frontiers of research between disciplines.

The amendment for two regional instrumentation centers can prove an invaluable aid in the service of medicine. All seven categorical institutes, as well as the Division of General Medical Sciences, would find in such centers strong arms for medical progress in their particular specialities, as well as in fields which overlap between Institutes.



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Choice of the name ASTRODATA reflects the branch of space age technology in which our people are well recognized – data control systems and ancillary instrumentation. ASTRODATA systems include a complete timing system on the Pacific Missile Range, operational checkout system for the Atlas missile at both Vandenberg AFB and Cape Canaveral, a high-speed, high-accuracy, data handling system for Bell Labs for use in conjunction with Nike Zeus tests at New Mexico's White Sands Missile Range, an automatic digital temperature recording system for monitoring temperatures within an atomic reactor, and a high-speed digital acquisition and processing system which speeds space probes at Lockheed's Missile and Space Division. Standard products include a wide range of time code generating, translating and tape searching equipment, dual mode amplifiers for low-level commutation and a variety of solid-state, plug-in modules.

Significantly, ASTRODATA now offers nationwide sales and service. For more information concerning the talent and capabilities of our company, write for a copy of *"This is Astrodata..."* to Astrodata, Inc., 240 E. Palais Road, Anaheim, California.

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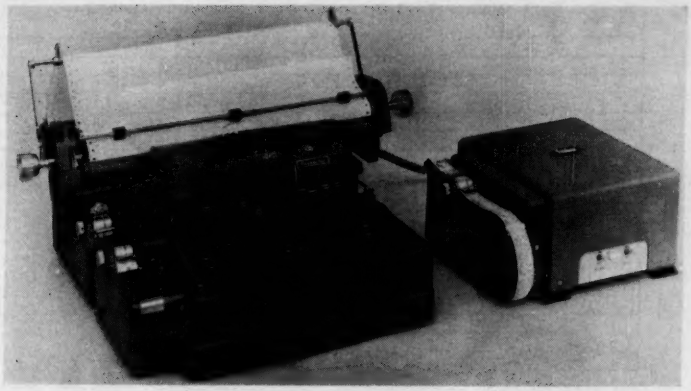


Numerical Control by Punched Tape

HENRY THOLSTRUP Friden, Inc.

Punched-tape dimensions and hole codes have been standardized, but different program codes (fixed sequential, block address, word address, tab sequential) are in use. A universal program code is being considered by Electronic Industries Association.

PUNCHED TAPE is the most popular method for numerical control of machining and metal-working operations.

The metal-removing industry, or machine-tool industry, has perhaps made the most use of numerical control to date, and has found that it can be applied to many processes and operations in industry such as (1) drilling, (2) boring, (3) milling, (4) turning, (5) shaping, (6) punching, (7) flame cutting, (8) welding and so on.

The basic considerations in use of punched tape include (1) tape dimension, (2) hole code and (3) program code. The first two have been standardized by the Electronic Industries Association, but several program codes are in common use.

Standards

Electronic Industries Association (11 West 42 St., New York 36, N. Y.) has issued the following "One-Inch Perforated Paper Tape Standard, RS-227"—issued Oct. 1959:

"The unpunched tape shall have an overall width of 1.000" ±0.003" after the tape has been conditioned to 73° F ±3.5° F and 50% ±2% relative humidity for a period of 24 hours (Fig. 1).

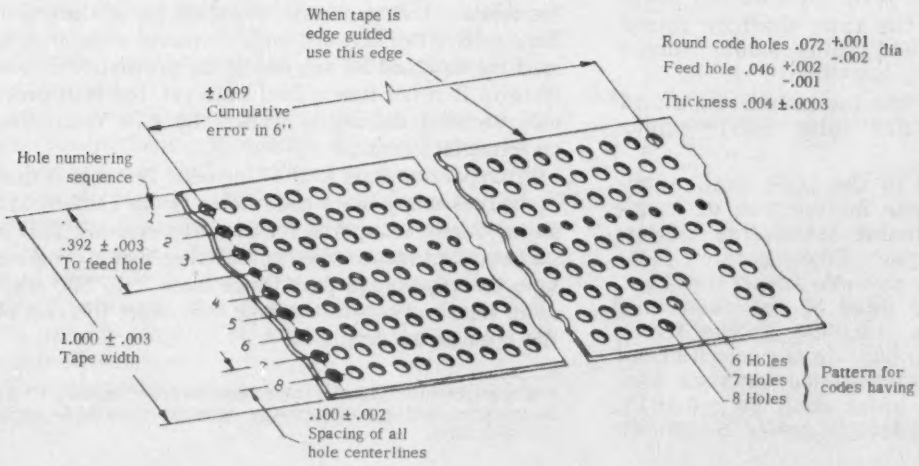
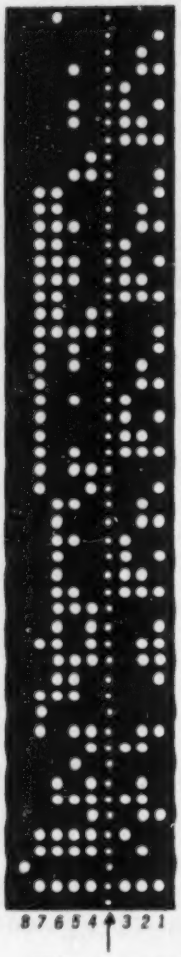

When tape is edge guided use this edge
Round code holes .072 +.001 -.002 dia
Feed hole .046 +.002 -.001
Thickness .004 ±.0003
±.009 Cumulative error in 6"
Hole numbering sequence
.392 ± .003 To feed hole
1.000 ± .003 Tape width
.100 ± .002 Spacing of all hole centerlines
6 Holes
7 Holes
8 Holes
Pattern for codes having

FIG. 1. DIMENSIONAL STANDARDS for punched tape. Track 1 is that track nearest the tape transport desk. (From National Aircraft Standard, tentatively accepted by the Aerospace Industries Association of America, Inc.)



Standard Track Numbers 8 7 6 5 4 . 3 2 1	Digit or Letter Codes	Standard Track Numbers 8 7 6 5 4 . 3 2 1	Digit or Letter Codes
6 .	0	7 5 . 3 2 1	p
. 1	1	7 5 4 .	q
. 2	2	7 4 . 1	r
5 . 2 1	3	6 5 . 2	s
. 3	4	6 . 2 1	t
5 . 3 1	5	6 5 . 3	u
5 . 3 2	6	6 . 3 1	v
. 3 2 1	7	6 . 3 2	w
4 .	8	6 5 . 3 2 1	x
5 4 . 1	9	6 5 4 .	y
7 6 . 1	a	6 4 . 1	z
7 6 . 2	b	7 6 4 . 2 1	. (period)
7 6 5 . 2 1	c	6 5 4 . 2 1	, (comma)
7 6 . 3	d	7 6 5 .	+ (plus)
7 6 5 . 3 1	e	7 .	– (minus)
7 6 5 . 3 2	f	6 5 . 1	/ (check)
7 6 . 3 2 1	g	7 6 5 4 . 3 2 1	Delete
7 6 4 .	h	8 .	End of Block
7 6 5 4 . 1	i	4 . 2 1	End of Record
7 5 . 1	j	5 .	Space
7 5 . 2	k	6 4 . 2	Back Space
7 . 2 1	l	6 5 4 . 3 2	Tab
7 5 . 3	m	7 6 5 4 . 3	Upper Case
7 . 3 1	n	7 6 5 4 . 2	Lower Case
7 . 3 2	o		

FIG. 2. STANDARD hole code. Presence of a track number indicates a hole. (From National Aircraft Standard, tentatively accepted by AIA.)

"The unpunched tape shall have a thickness of 0.004" ±0.0003" after the tape has been conditioned to 73° F ±3.5° F and 50% ±2% relative humidity for a period of 24 hours.

"The tape shall be used for recording six, seven or eight levels of information (tracks) across the tape. Track is synonymous with channel, or level, and runs along the tape. Row is across the tape.

"When the tape is edge guided, the guided edge of the tape shall be parallel with the longitudinal centerline of the feed holes and located 0.392" ±0.003" from the feed-hole centerline on the three-level side of the tape.

"The feed holes in the tape shall be round with diameter of 0.046" plus 0.002" minus 0.001".

"The code holes in the tape shall be round with a diameter of 0.072" plus 0.001" minus 0.002".

"All holes punched in the tape shall nominally center on the true intersection of longitudinal and perpendicular transverse centerlines spaced 0.100" apart. Tolerances on locations of code holes in any one transverse row, relative to the center lines of the feed hole in that row, shall be ±0.002" in the transverse direction and ±0.003" in the longitudinal direction. Tolerance on distance between centers of adjacent feed holes shall be ±0.001". Accumulated longitudinal errors between centers of feed holes shall not exceed ±0.009" within spans of 0.9" to 6".

"The measurement of all dimensions of the punched paper tape shall be made with the punched paper tape conditioned to the same environmental conditions under which it was punched."

Fig. 2 shows the standard digit or letter 8-hole code.*

Standardized Programming

Another phase of numerical control that the Electronic Industries Association committee is working on is a standard format of the punched-tape program. The objective is to permit the tape prepared for use on one machine to be used on other machines—that is, a tape prepared for one two-axis numerically-controlled (NC) machine should work on all two-axis NC machines.

Four methods of programming are shown in Fig. 3 for the numerical control tape prepared for the same part. The four systems are: (1) Fixed Sequential, (2) Block Address, (3) Word Address, and (4) Tab Sequential. Also, a format is shown for a Universal Tape which would work with a control system on a machine designed for any one of the previously-shown systems. It is not near a final state yet, but is at present receiving discussion within the EIA committee on numerical control.

Principal objection to the Universal Program is that it requires many more code holes (from 11½% to 31% more) than are required for the other systems. This is an important factor when considering that a program tape for an average part varies from 3' to 50'. Also, more time to prepare the tape will affect the cost of the part to be produced.

* Eight-channel tape is now considered "standard" by most users owning to its greater capacity than 5-, 6-, or 7-channel tape.

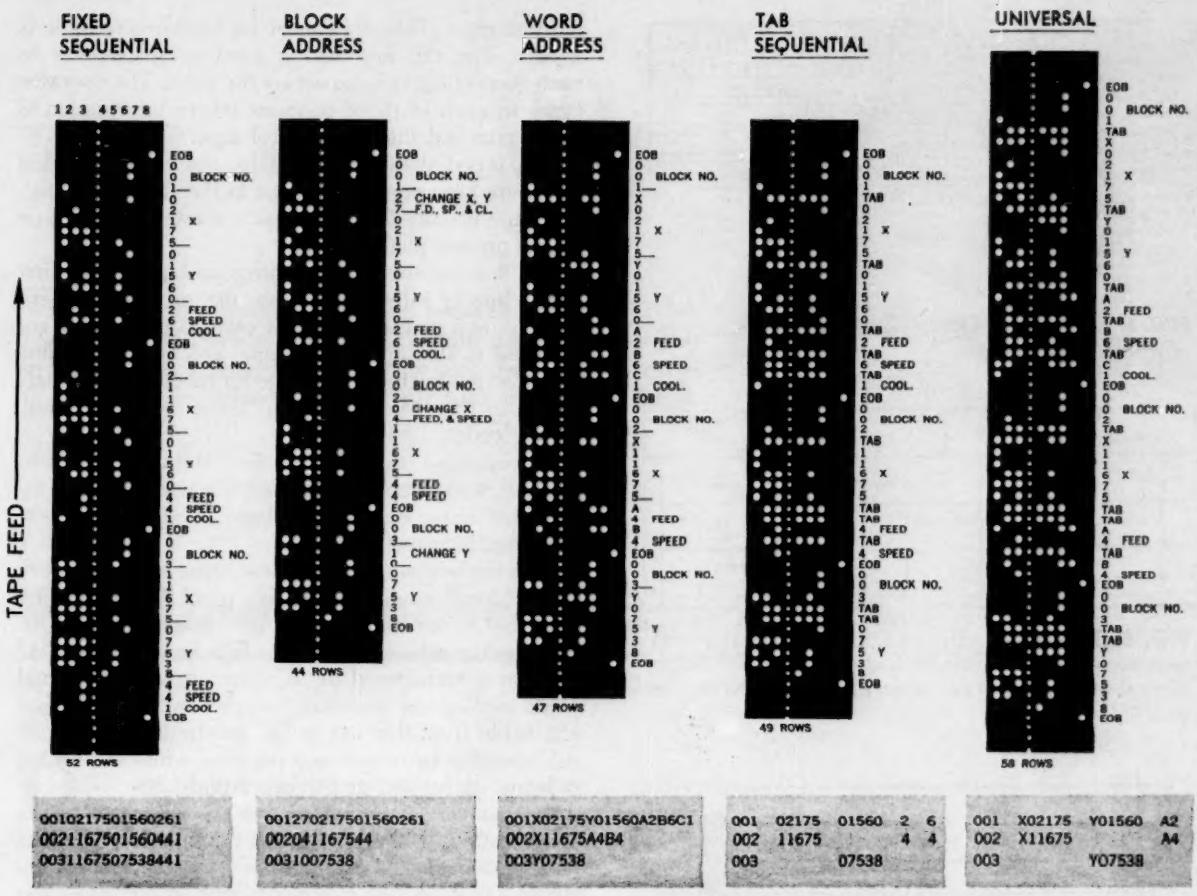


FIG. 3. UNIVERSAL PROGRAM at right can operate a machine designed to accept any of the first four programs shown and now in use. Blocks below the tapes indicate printed copy produced simultaneously with punching the control tape; the letters and numbers indicate feed, speed, coolant, etc.

Steps in Programming

All numerical-control programming formats are not alike; some operations require more information than others. Starting with the raw data, or an engineering drawing of a part (Fig. 4), the process planner studies the part to determine how it is to be made. He checks the standard tools that are in stock—drills, reamers, cutters, holding fixtures, etc. Any additional tools required are requested from the tool designer, who will design them and have them built. These special tools are usually holding fixtures used to mount the part properly on the work table of the machine tool.

The process planner is the focal point for all information pertaining to numerical control processing. He has to know the kind of tool used to cut or drill the specific material, the rate of metal removal (determined by the speed of the cutter), the feed rate or cutter movement into the workpiece, and the maximum allowable temperature of the workpiece or chips. These and other factors affect the life of the tools, the efficiency of operation, and the quality of parts produced.

To machine the casting shown in Fig. 4, the process planner develops the process planning sheet shown in Fig. 5. He enters a considerable amount of information (such as feed rate, slope, etc.) in addition to the X and Y coordinates; this is usually done manually, then checked.

Copy typing is done on the same sheet (Fig. 6); this typing automatically produces the master control tape. The sheet is positioned in the typewriter so that the tab key positions the carriage to the first possible sig-

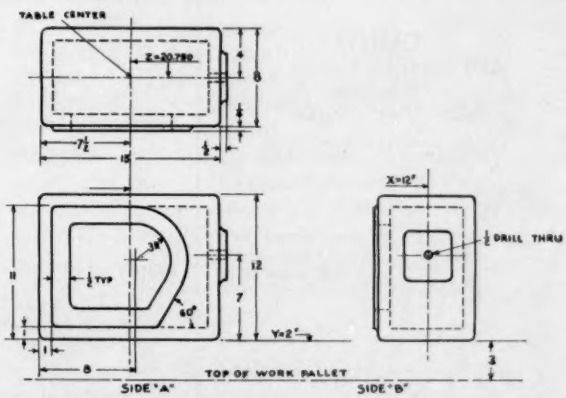


FIG. 4. TYPICAL engineering drawing of a part.

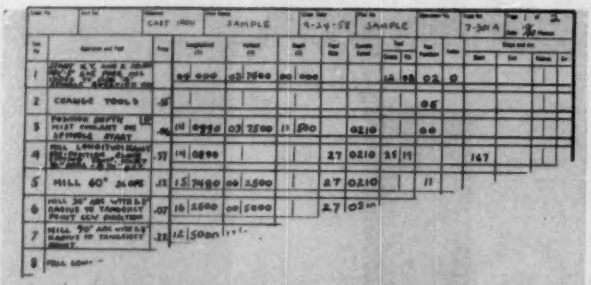


FIG. 5. KEARNEY & TRECKER Milwaukee-Matic process planning sheet.

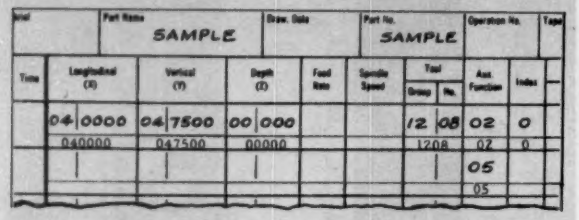


FIG. 6. TYPIST sets tab stops for each data column and types data in space provided directly below manual entry. Machine automatically produces the punch tape.

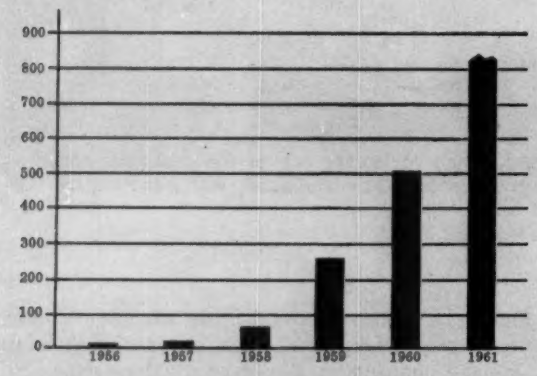


FIG. 7. NUMBER of numerical control systems sold for applications to machine tools.

nificant digit. This digit must be typed, even if it is a zero. The tab key also is used to space over to each succeeding column across the page. The operator types in each of those columns where information is to be punched into the control tape.

The typed data is verified by the planner and a duplicate tape punched for use in the shop. The original tape usually is retained as a master control tape by the process planner.

Fig. 8 shows the punched program tape for the first (top) line of information from the process planner's sheet shown in Fig. 5. In this case 33 code holes are punched in the tape for line one, and only 10 for line two. The complete control tape for machining the part shown in Fig. 4 would end up about 38″ or 40″ long. plus a leader.

The machine usually is run from the tape first without any workpiece or fixture on the work table to insure that some step has not been overlooked or programmed incorrectly.

Two readers can expedite processing when the work table is long enough to hold two parts. One is reading Section "A" instructions and the other Section "B." Usually, the same part that has been machined on "A" position is transferred to "B" position, and additional work is done on the part, usually on a surface not attainable from the first or "A" position. This permits the operator to reload one position while machining is being performed at the other position.

Program or numerical control tapes vary in length considerably, depending on the number of operations being performed. Most tapes will range from 18″ to 60″ in length. A few may be as long as 50′; there has been one 1,900′ tape used for a complex aircraft part.

Advantages of Numerical Control

Cost savings per part fabricated using numerical control vary from 20% to 90%, depending on tool cost, lead time, program complexity, etc. Experience with numerical control also indicates possible savings in increased life of cutting tools and reduction in scrap. Fig. 7 shows the growth in numerical control systems for machine tools.

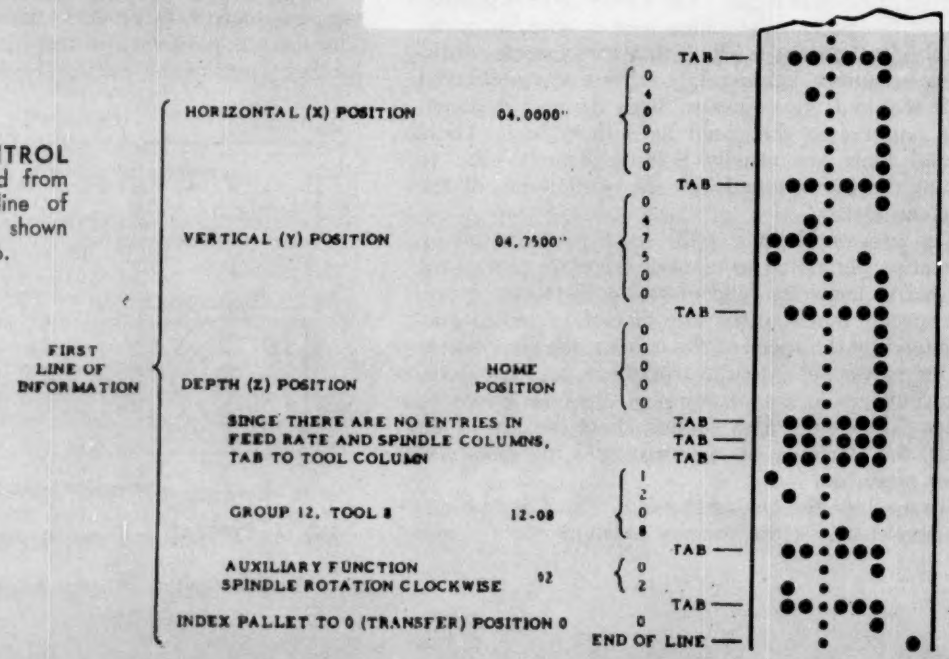

FIRST LINE OF INFORMATION
HORIZONTAL (X) POSITION 04.0000"
VERTICAL (Y) POSITION 04.7500"
DEPTH (Z) POSITION HOME POSITION
SINCE THERE ARE NO ENTRIES IN FEED RATE AND SPINDLE COLUMNS, TAB TO TOOL COLUMN
GROUP 12, TOOL 8 12-08
AUXILIARY FUNCTION SPINDLE ROTATION CLOCKWISE 02
INDEX PALLET TO 0 (TRANSFER) POSITION 0
TAB
END OF LINE

FIG. 8. CONTROL TAPE punched from data in first line of planning sheet shown in Fig. 5. and 6.

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Modern data applications require error-free high-speed reading of punched tapes. The basic techniques use mechanical or photoelectric sensing. New techniques permit photovoltaic readers to be priced competitively with mechanical types.

Reading Punched Tapes

FIG. 1. DESK-TYPE punched-tape reader.

ONE of the first major uses of punched paper tape was automatic message communication over telephone lines. The tape systems proved more accurate than manual telegraph, but, as message content was normally alphabetic, some error rate could be tolerated.

In recent years more and more numeric-type messages (containing accounting data, sales orders, and other dollar values) are being read and transmitted. Punched tape also provides input to business data processors, scientific digital computers, special-purpose computers, automatic test equipment, process controls, and machine-tool controls. Error rates here must be greatly reduced—and reading speeds must be increased because of the increased volume of data.

Punched-tape-reader requirements for these applications vary, but the basic requirements are reading speed, accuracy, and life. Reading speed usually is stated in lines, or characters, per second. Reading speeds can be divided roughly into two ranges—(1) below 200 lines/second and (2) above 200 lines/second. Message communication, automatic test equipment, process controls, machine-tool controls and some computers use the low-speed readers. Most data processors and other types of digital computers require the high-speed readers.

Error-free reading, desirable in all applications, is essential when punched tape is used to control automatic equipment. Elaborate checking and even correction circuits have been used to provide reliable error-free operation, but this raises the cost of the equipment.

Basic Techniques

Punched-tape readers generally use either *mechanical* or *photoelectric* techniques.

Mechanical readers sense the punched holes by using pins, pronged wheels, brushes, wires, pressurized air, etc., to close an electric contact through the holes in the tape. Mechanical readers have been used in most of the low-speed applications because of cost. However, use of a contact limits the speed to about 20 lines/second (a few models run as high as 100 lines/second). Contacts also reduce reliability and life below that possible with photoelectric technique.

Photoelectric readers sense the punched holes by activating a light-sensitive device, with light passing through the hole or reflecting off non-hole areas of the tape. Speed is limited only by photocell response or the operation of the tape-handling mechanism. Photocell readers are used for high-speed applications (300, 400, 500 and 1000 lines/sec).

Cost

In the past, photocell readers have cost 3 to 10 times more than mechanical readers because (1) the cost of photodiodes, phototransistors, or photomultiplier tubes used for each tape track is high, (2) the optical alignment of individual cells requires accurate, complex holding fixtures, (3) low-drift circuits that compensate the variables and drift of the cells are relatively costly (a-c chopping schemes sometimes are used to reduce drift problems), and (4) tape transport mechanisms often have been copies of costly magnetic-tape transports. However, use of photovoltaic detectors and inexpensive transports now permit photocell readers to be priced competitively with mechanical readers.

Reliability Factors

Reliability and life of mechanical electric contacts are affected by many factors including temperature,

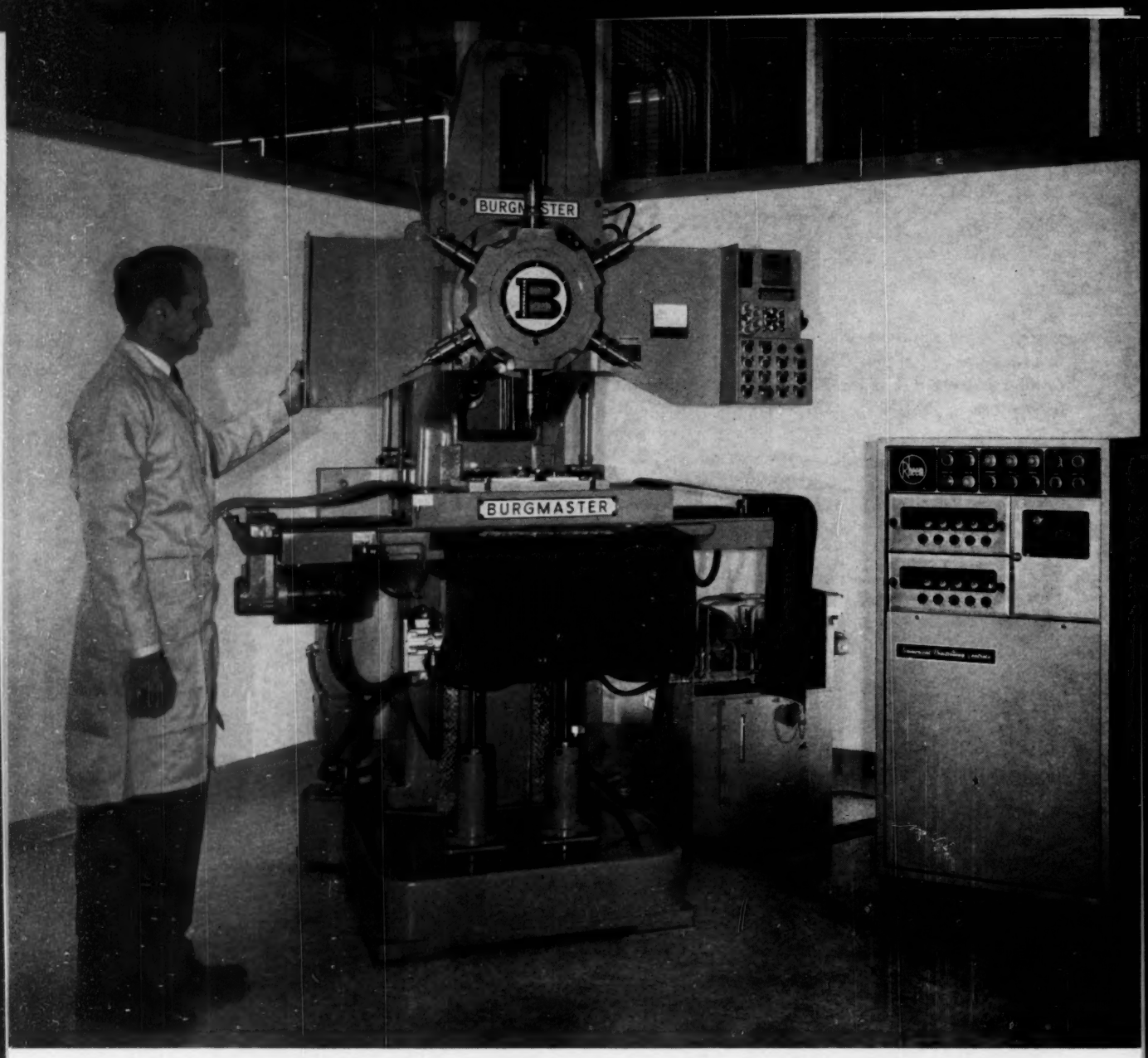

FIG. 2. MACHINE-TOOL numerical positioning control system with punched-tape reader.

humidity, voltage, current, type of load, and type of switching (wet or dry circuit). Contacts must be cleaned and adjusted periodically to operate reliably. The reliability and life of photoelectric systems depend on the short- and long-term drift of the photocells, amplifiers, light source and optical system.

Photodiodes and phototransistors vary considerably from one unit to the next and drift with time and temperature. The more recent photovoltaic cell, which converts light energy directly into electric energy, has low temperature and time drift. A unit for all channels of a reader can be made from the same piece of silicon, making the variation from cell to cell small (typically ±10%).

The drift problem with photovoltaic cells can be solved by designing an amplifier that will operate under minimum cell output. By providing sufficient bias for transistor leakage, it is possible to provide high output currents with a one-stage transistor amplifier.

A reliable low-cost tape transport can be designed for moving tape at speeds up to 150 lines/second. Use of photovoltaic cells and such a transport have reduced the price of photocell tape readers to that of mechanical readers.

Laboratory tests have been made with such a tape transport operated in a start-stop fashion for each line of tape at 60 lines/second for over 1000 hours, providing 3,600,000 operations with no degradation of performance.

Assured error-free operation allows elimination of much error-checking circuitry. Also, tape life is lengthened because tape can be fed with pinch rollers rather than indexed by sprocket holes.

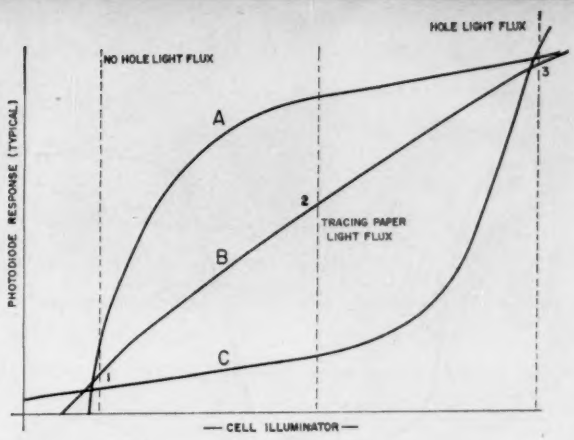

FIG. 1. PHOTODIODE CHARACTERISTIC (electric signal output versus flux input) can be linear or nonlinear. Linear characteristic is most stable and safest.

Photoelectric Paper-Tape Sensing

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Digitronics Corporation

Photoelectric paper-tape sensing requires consideration of (1) photocell and amplifier characteristics, (2) mechanical considerations and (3) paper-tape handling problems. Over-all system and reliability implications are discussed.

PAPER TAPE is becoming an increasingly important medium for data storage in many applications. Once used only for message communication in 5-channel Teletype systems, paper tape now is being applied to many problems which had been handled previously by punched cards and magnetic tape (both digital and analog).

The advantage of paper-tape systems include:

1. Relatively low cost of paper-tape handling equipment.
2. Increase of data rate over corresponding card systems.
3. Ability to physically separate items, together with completely variable item length.
4. Low susceptibility to environmental dirt, humidity and electrical interference.
5. Relative indestructability of master tapes (when proper materials are used).
6. Extremely high reliability (when the proper equipment for the proper speed is chosen).

Paper-tape *preparing equipment* is, at present, completely mechanical. Paper-tape punches now operate at up to 300 characters per second with reasonable reliability, given careful maintenance. (Combined electronic plus mechanical techniques are being developed which will achieve substantial increase in speed and reliability in the near future.)

The present discussion, however, is concerned with the paper-tape *reading* process. Experience has shown good reliability at speeds up to 20 characters per second with mechanical equipment. Although mechanical readers have operated well at speeds up to 100 characters per second, photoelectric sensing units are recommended for speeds between 20 and 2000 characters per second.

Sensing

Photoelectric sensing depends on the difference between the light transmitted through a paper-tape (or in some systems, not considered here, the light reflected from the paper) compared to the direct light through a hole in the paper. A second factor in sensing is the conventional arrangement of a sprocket hole whose diameter is less than, and longitudinally centered in, the data holes. The leading edge of the sprocket hole can be used to allow sampling of the data holes with assurance that all data holes have, by that time, reached a stable "one" or "zero" bit configuration. A third factor in sensing is the transverse alignment of the holes in the paper with respect to the sensing photoelectric elements. (Alignment troubles can result when reading tapes whose sprocket position varies transversely due to punch misadjustment; such tapes read well on mechanical readers which guide on the sprocket but not on photoelectric readers which guide on the edge of the paper.) Finally, the tape must not be allowed to flap excessively over the sensing head because spurious readings can result.

The *transmissivity* of paper tapes varies from complete opacity to 80% transmissivity. There are otherwise relatively opaque tapes which contain defects or, in some cases, oil spots which radically increase the transmissivity. For "digitally safe" paper-tape sensing it is well to assume a maximum paper transmissivity and to design for signal-to-no-signal ratios of no more than 5:1.

Fig. 1 shows photodiode response as a function of illumination. Curves A, B and C show possible responses of a photoelectric transducer. (These curves can be shifted by electrical parameters of the sensing

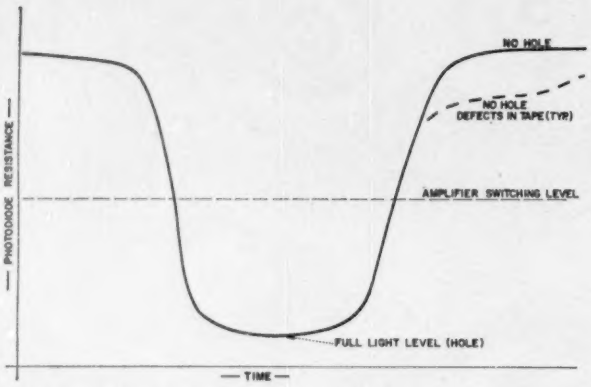


FIG. 2. AMPLIFIER is set to switch on at a diode resistance level well below that which would be due to light transmitted through common defects in paper.

circuit.) Note that although all three curves have similar signal-to-noise-signal ratios at the referenced (no-hole and hole) illumination, curve B affords the most stable (and hence most reliable) characteristic.

Linear characteristics are readily obtainable from reverse-biased silicon photodiodes. Variations between photodiodes can be accommodated by variable circuit parameters so that an inspection procedure can guarantee a properly centered response curve. The practice of inserting a "tracing paper" filter in the inspection jig to establish a third point on the response curve (no hole, hole, tracing paper) is useful, as reference to Fig. 1 shows.

The physical configuration of the photodiode, each with its own rounded lens, has advantages. The diode is mounted with its lens just protruding from the head block so that the paper tape, passing over the lens, continually clears dirt from the optical path. This feature is useful in machine shop or dirty environments.

The amplifiers following the photodiode can be simple. Good digital practice suggests that all stages be completely nonlinear—i.e., completely on or completely off as a function of the hole or no-hole condition of the light to the photodiode. Fig. 2 shows the setting which is used to assure reliable digital operation. Note that the diode resistance level for common defects in the paper is still well above the amplifier switching level. This assures a high degree of immunity to spurious responses. In addition, the full light level affords ample current drive to the amplifier. These conditions can be guaranteed best by a single control for each channel plus rigid stabilization of the lamp voltage. With such a setting, wide variations in environmental conditions can be tolerated safely.

The sprocket channel amplifier for most paper-tape systems should serve as a "strobe" for the data channels. To assure proper waveshape for this strobe it is good practice to include a regenerative circuit as a Schmidt trigger circuit in the sprocket amplifier. The output of the sprocket circuit then can be used optionally to gate the data channel outputs on an "AND" basis. If such logical capabilities are provided it becomes simple to arrange a "Stop character memory." (This means that when the stop command is given the reader, the last character is stored in the amplifiers even though, at high speeds, it is usually desirable to have the tape stop just beyond the "stop" character.)

Chadless Tape

Finally, in sensing, it has been common in Teletype practice to use "chadless" tapes. Such tapes are not punched out completely and are useful where it is desired to print the message on the tape. Mechanical readers have no difficulty in sensing these incompletely punched holes since the sensing pins can readily deflect the "chad" sufficiently to effect a reading.

Photoelectric sensing requires that some other means be used to deflect the chad. Some tape readers have attempted this at high speed by sensing the holes just after the tape has passed over a sharp bend, or as an air blast deflects the chad. Wide experience with such readers is not yet available. However, the desirability of decreasing reliability for the sake of being able to print on the tapes should be questioned. When tape is handling data at up to 1000 characters per second, the need for chadless interpreted tape in the system becomes questionable.

Motion Control

As the reading speed increases, the ability to stop the tape rapidly becomes more important. The command to stop might come from a code on the tape and, if the tape does not stop before the next character, stages of buffer memory become necessary. As the section of tape to be stopped has low inertia, stopping in a few milliseconds does not require much force. However, the associated mass of tape reels can add considerably to the required force. Starting, on the other hand, is not as critical.

Traditional paper-tape transports used a sprocket wheel to drive the tape. As stopping the sprocket wheel in less than one character position at high speeds is difficult, the magnetic-tape transport technique (involving a pinch roller and capstan plus a brake) offers an excellent solution to this problem.

As paper tape is not damaged readily by wear, the braking action need not include mechanical motion of the brake parts. The brake can rest on the paper tape during the motion period. Then, when the stop command is given, it is necessary only to build up the magnetic field. The resulting increase of normal force and corresponding friction can stop the tape quickly. The brake will become operative while the pinch roller and captsan are still disengaging. It is worthwhile to have the brake and pinch roller assemblies on opposite sides of the head so that the resulting tension in the tape during the stopping period helps prevent tape flap.

After the tape has come to a stop the brake pressure should be maintained to avoid accidental tape motion. (This is particularly true of any type of paper-tape-handling equipment associated with the reader.) Consider the possibility that the tape will stop with the light slit edge just beyond a sprocket hole. A small back and forth jitter of the tape as the pinch roller engages will allow a spurious signal to be generated which will throw the next item out of sequence.

TABLE 1—CAPABILITIES OF TAPE-HANDLER TYPES AT MAXIMUM SPEED

Unit	10" Reel *(1000 ft)	8" reel *(500 ft)
Winder	2 IPS** (20 CPS***)	12 IPS (120 CPS)
Spooler	25 IPS (250 CPS)	50 IPS (500 CPS)
Servo	60 IPS (600 CPS)	100 IPS (1000 CPS)

*Standard type NAB reel, using 4.5-mil tape.
**IPS = Inches per second
***CPS = Characters per second.

Fig. 3 shows a bidirectional paper-tape reader. The pinch roller and capstan assemblies are most remote from the head. This assembly could be closer to the head in order to minimize required paper-tape leader. However, this would mean pushing the tape through the brake associated with the opposite direction of motion, and a corresponding possibility of jamming. The design shown allows for a minimum 6" leader together with bidirectional operation.

Paper-Tape Handling

The relatively large mass of reels and paper tape requires that a mechanical buffer be inserted between the reader and the reel when paper-tape speeds increase over 2 inches (20 characters) per second. Depending on the size of reel and the speed, a number of tape-handling configurations can be used. Listed in order of increasing cost these configurations are:

1. Winders—Unwinders
2. Spoolers
3. Servos

Winder units involve simple tension-arm-controlled drives. So long as the tension arm is away from a home position, the winder motor is operative and pulls tape. The tension arm of the unwinder simply acts to brake the reel motion when the slack loop gets too big.

Spooler units (Fig. 4) use reversible torque motors on both the take-up and feed reels. The tension arms each operate in three zones—*central zone* (de-energizes the motor), *maximum-loop zone* (causes full take-up torque), and *minimum-loop zone* (causes full feed-out torque). Various interacting controls are designed to allow for tape breakage, rewind, etc. As the reader accelerations and decelerations are virtually instantaneous compared to reel motions, a set of straightforward relationships can be derived between tape speed, reel size, tension arm travel and the required motor torques.

Servo units (Fig. 5) have greater control abilities than spoolers because the control function is continuous (or at least multi-zone) and with variable torque.

Table 1 shows comparable capabilities of these various tape handlers.

If the reader and tape handler have been chosen properly, reliability rates in the order of 1 error per 10^{10} bits are attainable. As the popularity of punch-tape equipment increases, lower costs are being announced so that the cost-reliability criteria of paper-tape operation becomes evermore attractive.

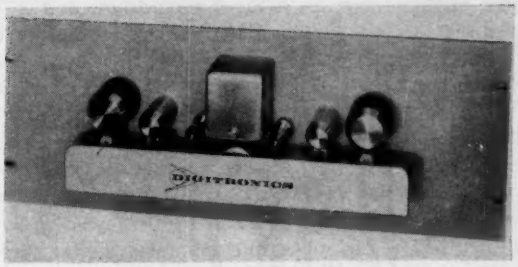


FIG. 3. BIDIRECTIONAL Tape Reader Model B3500.

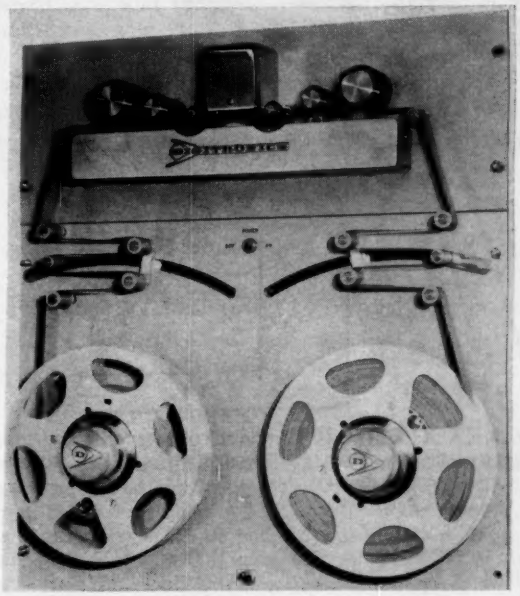


FIG. 4. SPOOLER Model 4588 will handle 500 feet of paper tape or 1000 feet of Mylar tape bidirectionally at 500 characters per second.

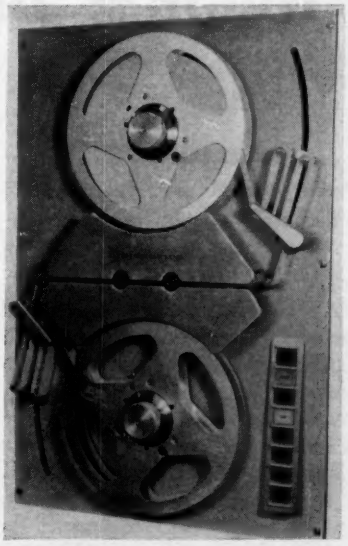


FIG. 5. SERVO-TYPE tape handler Model 4500. This reader plus servo-controlled reels for tape handling will operate at 600 characters per second.

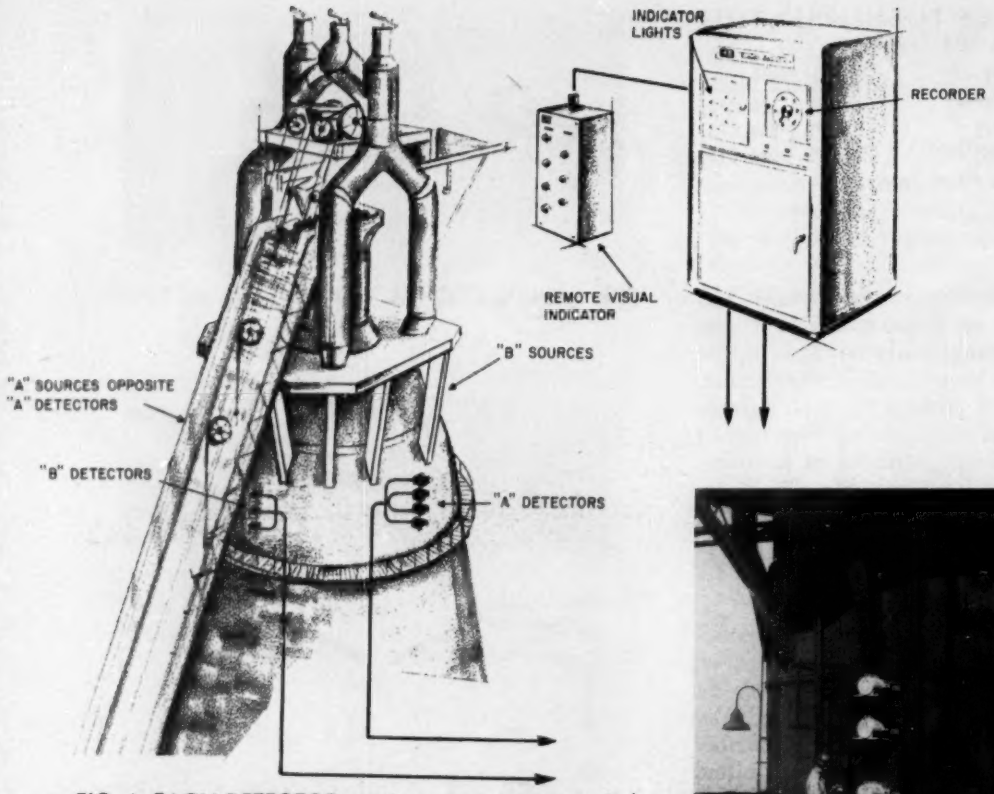


FIG. 1. EACH DETECTOR monitors one source mounted on opposite wall of furnace. Each source-detector beam is at different level. "A" detectors monitor "A" sources; "B" detectors are mounted 90° around furnace wall and monitor "B" sources. "B" beams are at intermediate levels in between "A" beam paths. Indicator lights reveal which beams are occluded by stock. Installation at right is on a Republic Steel blast furnace.

Nuclear Burden-Level Gage

FRED LONDON
Airborne Instruments Laboratory
A Division of Cutler-Hammer, Inc.

STOCKRAY is a continuous measuring device using nuclear techniques to detect and monitor burden level, the level of stock charged into a blast furnace.

The conventional means of determining blast-furnace burden level is the mechanical stockline gaging system that has been in use for the past 30 years. It operates on the principle of an automatic tension-sensitive hoist that lowers a weight into the furnace through a hole in the furnace top. When the weight rests on the stock the cable goes slack and the length of cable paid out indicates stock level.

The high production rates of modern blast furnaces have focused attention on two major limitations of the stockline gage—maintenance and gas leakage. Furnace shutdown for stockline gage repairs now means greater cost in terms of lost iron production. Higher blowing rates and high top pressures also have resulted in increased gas leakage with the conventional gaging system.

Stockray uses an arrangement of radioactive sources (Fig. 1), emitting gamma rays on one side of the furnace, and a corresponding arrangement of radiation detectors on the opposite side. The detectors recognize the presence or absence of gamma radiation directed from the sources. When the stock inside the furnace obstructs a radiation beam, it reduces the signal to the corresponding detector. A signal-light arrangement representing each stock-level detector indicates when the burden drops below each detector level. By proper arrangement of the lights, a graphic

distribution of the stock level can be seen. Bell dumpings, as well as stock levels, can be indicated on the recorder.

One typical application consists of four separate sources and detectors aligned in an east-west direction, and three separate sources and detectors monitoring intermediate levels in the north-south direction.

The specific gaging levels are:

DISTANCE BELOW BELL (FEET)	BEAM DIRECTION
6	east-west
7	north-south
8	east-west
9½	north-south
11	east-west
12½	north-south
14	east-west

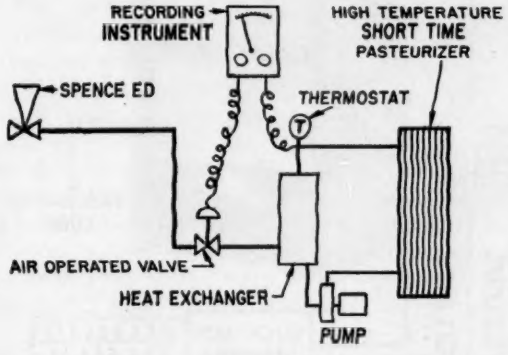
Gamma rays are used both for their penetrating power and safety. The gamma-ray emitter is cobalt 60. It does not induce radioactivity in any material it strikes. Its half-life is 5.3 years, and the source material can be used without replenishment for at least five years of continuous operation.

A detector box is located on the opposite side of the furnace from each source. Geiger-Muller tubes are used and have long life. Incorporated into each detector unit is a minute source to check for proper detector and associated amplifier operation. With the minute test sources in each detector, the entire system can be tested and calibrated from the control cabinet, thus eliminating trips to the top of the furnace.

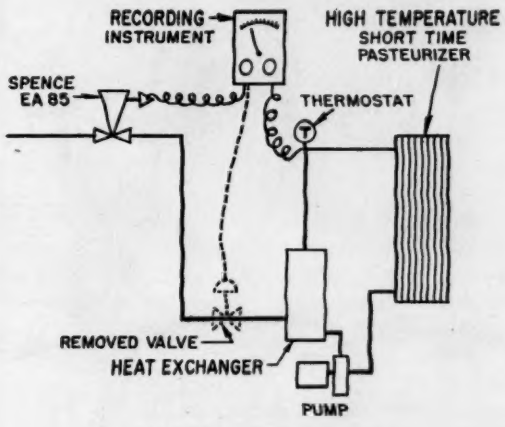
Stock level is measured accurately and continuously at all times, a general indication of stock distribution or contour is provided, gas leakage common in conventional control systems is eliminated, maintenance can be performed easily and quickly without furnace shutdowns, and the system can be adapted to automatic charging control and other automatic control possibilities. One installation has been in continuous operation for over two years with no furnace shutdown for maintenance work; the furnace on which it is installed has been operating at record-breaking production levels.

PROCESS CONTROL

PILOT-OPERATED REGULATOR REDUCES STEAM PRESSURE AND CONTROLS TEMPERATURE



OLD HOOK—UP



NEW HOOK—UP

In the process of pasteurizing milk for cheese production, temperature has to be controlled within ±5°F.

The conventional process control system (shown in Fig. 1) includes a steam pressure reducing station (Spence ED) and a control valve in the line to the heat exchanger. The control valve receives its pneumatic signal from a temperature recording controller. A thermostat (T) senses the temperature in the outlet of the heat exchanger which provides hot water to the pasteurizer.

Whiting Cheese Co., in Gillet, Wis. had used this system until parts of the control valve wore out. Instead of rebuilding the control valve, a simpler and cheaper solution was found in the use of an air-pilot-operated pressure regulator which replaced the control valve and the pressure-reducing station. The air output of the temperature controller was connected to the pilot and the latter installed on a pressure regulator in the inlet line of the heat exchanger. Steam pressure is reduced from 125 psig to 35 psig, and the water supply of 125 gpm and 160°F is accomplished with greater accuracy than before.

Equipment required: Pressure Regulator Type EA85. Reverse-acting temperature recorder-controller (any reputable make).

Source: Spence Engineering Co., Walden, N. Y.

Digital Radar...

A NEW TECHNIQUE WORTH STEALING EVEN IF RADAR ISN'T YOUR BUSINESS

This digital ranging radar system features COMPUTER EQUIPMENT's Quantizer* technique—a solid state time interval-to-digital conversion system with 10 nanosecond resolution, 10 part per billion accuracy of resolution and the ability to measure in excess of 500,000 time intervals per second.

Available in BCD or straight binary formats, the Quantizer is compatible with virtually any digital data processing approach while its high sampling rate capability opens the door to real time computer processing of dynamic data. It's a technique worth "stealing" for a wide range of applications, including:

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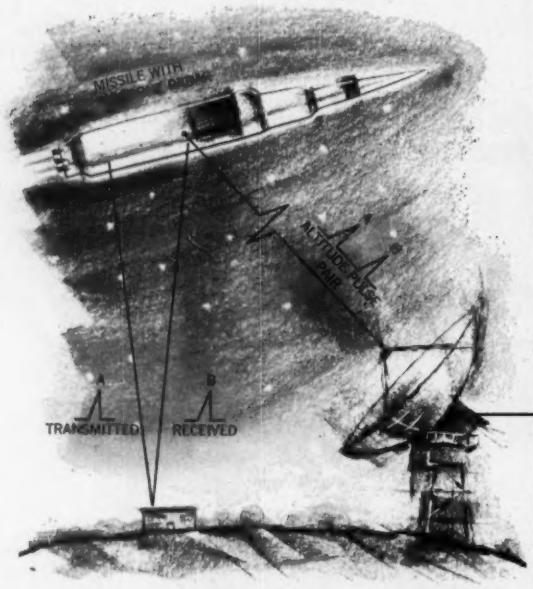
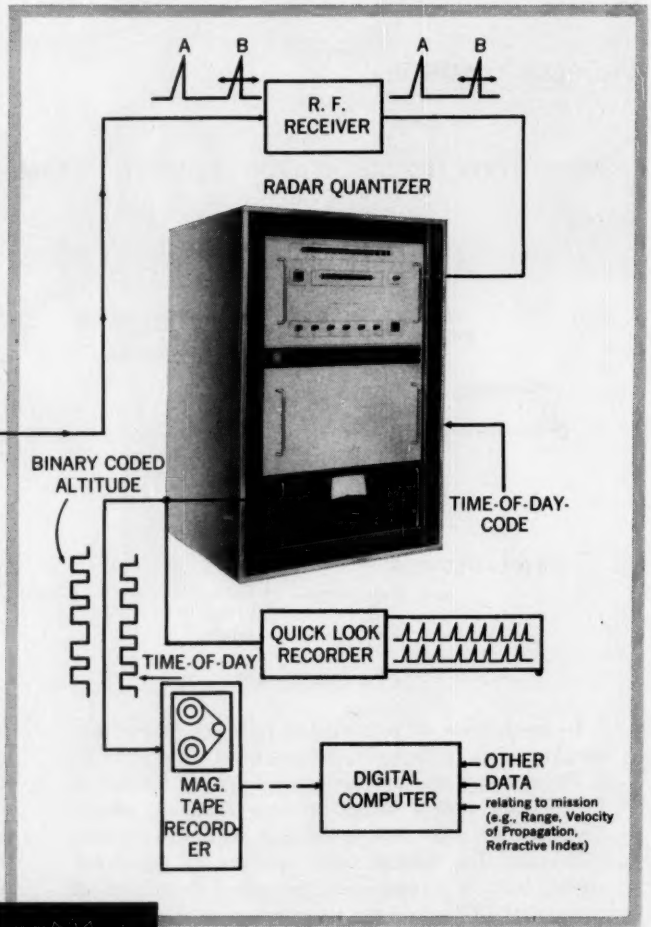
* *Radar ranging*
* *Digital Doppler*
* *Space-time-velocity-acceleration measurements*
* *Circuit propagation time*
* *Ballistic trajectory determination*
* *Shock tube and plasma studies*
* *Explosive burning studies*





HIGH-RESOLUTION DIGITAL ALTIMETER—Altitude of a missile is measured with resolution of 5 radar feet through time-to-digital conversion techniques developed by Computer Equipment Corporation. It works as follows: Ranging pulse A, transmitted from missile, is detected by ground station and triggers a time-to-digital conversion in Quantizer. This represents "start" of time interval whose total duration will be the radar echo time. When Pulse B, echo of Pulse A, is received by the airborne unit, it is retransmitted to the ground. Its arrival at ground station signifies "stop" of the time interval of interest and time-to-digital conversion. To facilitate data interpretation, time of day code is continuously inputted to the Quantizer and combined with radar data. Quantizer output is recorded digitally for data reduction at computer center and also presented on graphic recorder for "quick look" purposes.

COMPUTER EQUIPMENT will be happy to supply more data and propose a Quantizer for your specific application. Contact your COMPUTER EQUIPMENT engineering representative, or call, wire or write us directly.

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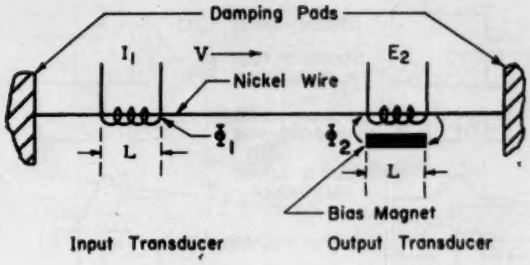


FIG. 1. MAGNETOSTRICTIVE sonic delay line comprises nickel wire plus two magnetostrictive transducers. Input transducer converts input pulse signals (I_1) into dimensional changes in the wire. Delay results from time required for sonic pulses to travel to output transducer, which reconverts sonic pulses into output signals (E_2).

Delay Line Memories

Magnetostrictive sonic delay lines have become a popular type of storage. They can provide a small low-cost memory for computers with a clock rate from 500 kc to 2 Mc.

DAVE ELLIS, Burroughs Laboratories

ANY DEVICE that delays the passage of digital information can be said to store that information for a time equal to the delay time of the device. If the delayed information is fed back from the output to the input, it may be stored indefinitely as a pulse or pulse train moving continuously, or recirculating, around the delay loop. The use of delay lines as storage elements in digital computers is based on this principle. As the data or stored information is in continuous motion, the technique is one of dynamic storage, as opposed to the static storage provided by magnetic cores, tapes, drums, and discs.

Electromagnetic and Sonic Delay Lines

Delay lines are of two general classes—electromagnetic and sonic.

Electromagnetic delay lines are simply transmission lines carrying pulse trains. As the delay time generally available is not sufficient to store a large number of pulses (unless lines of enormous length are employed), this type of delay is not suited for conventional computer memories.

Sonic delay lines convert electrical input pulses into sonic pulses (sound waves), delay these pulses, and reconvert the sonic pulses to electrical pulses at the output. As sound travels much slower than electricity, the sonic delay technique provides a much greater delay time through a given length of delay medium than does the electromagnetic technique.

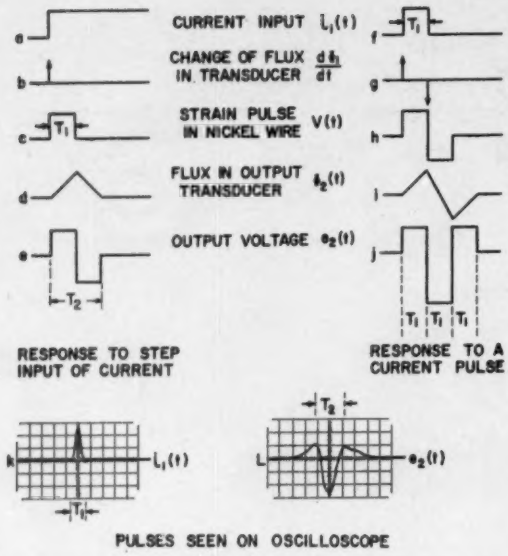
Several computers use sonic delay lines for storing digital pulses. The early Univac computer[1] used columns of mercury as the delay medium, with quartz piezoelectric crystals to convert electrical energy into sound energy, and *vice versa*. However, this technique is expensive and cumbersome compared with the *magnetostrictive sonic delay line*, a more recent development which has become the principal type of delay-line storage in modern systems.

Magnetostrictive Sonic Delay Lines

Several computers using magnetostrictive sonic delay lines as the storage element[2] have appeared on the market. This type of delay line (Fig. 1) uses acoustic delay in a metal wire. A transducer at the input converts the electrical inputs into sonic signals by using the principle of magnetostriction*; a similar transducer reconverts the sonic signals at the other end of the wire into electrical signals, also by using magnetostriction.

As there is no place to store the pulses in the wire for a long period of time, the data must be recirculated from the output to the input. Recirculation can be continued indefinitely before the data is used. A small

* Magnetostriction—the change in dimension of certain metals, such as nickel, when subjected to a magnetic field.


CURRENT INPUT $i_1(t)$
CHANGE OF FLUX IN TRANSDUCER $\frac{d\phi_1}{dt}$
STRAIN PULSE IN NICKEL WIRE V(t)
FLUX IN OUTPUT TRANSDUCER $\phi_2(t)$
OUTPUT VOLTAGE $e_2(t)$
T_1
T_2
RESPONSE TO STEP INPUT OF CURRENT
RESPONSE TO A CURRENT PULSE

PULSES SEEN ON OSCILLOSCOPE

FIG. 2. IDEALIZED waveforms. T_1 is due to the length of the transducer coil and equals length of coil/velocity of strain wave on the wire.

amount of recirculation logic is used to resynchronize the data and reinsert it into the input transducer. Pulses are synchronized with the system clock each time around the recirculation loops. Thus, each bit of information can be located at a definite place in the loop at any specified time. The total delay through the line must be known and held constant to within a close tolerance.

Binary ONEs and ZEROs are represented either as (1) pulses of equal amplitude but opposite polarity, or (2) pulses and absences of pulses.

Environmental effects, particularly temperature, affect the sonic waves traveling down the wire, but the recirculation logic could be designed to recognize and correct the resultant variations in signal amplitude and timing due to environmental factors.

When compared to other storage devices, delay lines of this type offer an interesting compromise in speed, access time and cost-per-bit. They are less expensive but have longer access time than core storage; they have shorter access time but cost more per bit than disc or drum storage. They appear to be most useful where a small, low-cost memory is desired in a digital computer having clock rates of from 500 kc to 2 Mc. A typical magnetostrictive delay unit might operate, for example, at 1 megacycle/second and store 10,000 bits per delay line.

Magnetostrictive Transducers

In the basic form of the delay line (Fig. 1) a piece of magnetostrictive nickel wire is suspended between pads of acoustic damping material. The dimensions of the nickel wire are altered by the application of a magnetic field. For example, if a magnetic field is applied along the axis of the wire, the wire gets shorter. If a magnetic field impulse is applied to a small part of the wire, a dynamic strain pulse is made to travel down the wire with the velocity of sound. The precise velocity of the strain pulse depends on the mechanical properties of the wire material; the shape of the pulse depends on the magnitude and rate of change of the magnetic field.

In a simple delay line, a coil of wire at one end of the delay wire serves as the input tranducer, and a coil at the other end as the output transducer. The input transducer converts a current pulse into a mechanical strain wave on the wire, and the output transducer reconverts this mechanical wave to an electrical signal. The delay time through the line is simply the distance between the transducers divided by the velocity of sound in the wire.

Waveforms

Idealized waveforms for the delay line of Fig. 1 are shown in Fig. 2. The waveforms corresponding to a *step of current* applied to the input transducer are represented by figures 2a through 2e.

The effect of the transducer coil length on the strain wave is indicated in figure 2c: the minimum length of the strain wave is equal to the length of the transducer coil. Thus, the minimum time duration of the strain wave, when observed at a fixed point on the wire, is $T_1 = L/V$, where L is the length of the transducer coil and V is the velocity of the strain wave on the wire. As the physical length of the strain pulse and its time duration at a fixed point in the wire are related by the linear velocity term, the shape of the mechanical strain wave on the wire is similar to the shape of the strain wave.

In the region of the output transducer, a small permanent magnet creates a bias flux in the nickel wire. As the presence of strain changes the permeability of the wire, the flux linking the transducer coil (Φ_2) changes in proportion to the amount of the strain pulse under the coil. If the length of the output transducer is equal to that of the input transducer, the resulting flux change is as shown in figure 2d. The maximum flux change occurs when the strain wave is centered under the output coil. The induced voltage output from the coil (figure 2e) is proportional to $d\Phi_2/dt$.

The waveforms in figures 2f through 2j show that an input pulse of duration $T_1 = L/V$ causes the output shown in figure 2j. This output results from the superposition of two input current steps which are of opposite polarity and displaced from one another in time.

Figures 2k and 2L (bottom) show the actual waveshapes corresponding to the ideal waveshapes of figures 2f and 2j. The departure from the ideal is the combined effect of many non-ideal conditions in the device, including input pulse rise-time, electrical (magnetic) hysteresis in the material under the transducer coils, mechanical hysteresis in the delay wire, and dispersion due to internal reflections.

Several analyses have been made of these waveshapes.[3-7] From these, the optimum conditions for operation of the line have been determined. The time T_2 (figure 2e) is equal to approximately $2T_1$, twice the duration of the input pulse. A separation of $2T_1$

between input pulses represents a compromise between pulse resolution and pulse repetition rate. The optimum transducer coil length can be found by $T_1 = L/V$, where L is the effective length of the magnetic field of the input coil, and V is the velocity of sound in the nickel wire.

Longitudinal Versus Torsional Mode

The basic magnetostriction delay line described transmits strain waves along the delay wire in the form of compressions and elongations along the axis of the wire. This is referred to as the *longitudinal mode*. Solids also can transmit strain waves in the shear mode; a torsional moment in a thin wire causes pure shear mode strain. This is referred to as the *torsional mode*.

Delay-line operation in the torsional mode has several advantages over operation in the longitudinal mode, especially where long delays are required. The velocity of shear strain waves is only 60% of the velocity of longitudinal waves; thus, more delay is available with the same length of delay line. Torsional-mode waves also suffer less dispersion in the delay wire than longitudinal-mode waves. Whereas longitudinal waves are dispersed by any bending or forming of the delay wire, the torsional mode delay wire is almost free from these effects when certain precautions are taken.

The advantages of torsional propagation are offset by one major difficulty—that of producing torsional-mode stress in the delay wire directly by a transducer. This difficulty is overcome at the input by first generating longitudinal-mode waves and then converting them to torsional-mode waves in a "mode converter." At the output of the line, a reconversion to longitudinal-mode waves is performed for the output transducer.

For a typical torsional-mode delay line, both the input and output mode converters take the form shown in Fig. 3. Thin nickel tapes are welded to the top and bottom of the delay wire. Each tape passes through a separate coil in the transducer proper. A permanent magnet in the transducer establishes a bias flux Φ_B in the tapes surrounded by the coils. When current is applied, the flux from the upper coil aids the bias flux; the flux from the lower coil opposes the bias flux. This causes a compression and an elongation in the upper and lower tapes, respectively. These two opposing strain waves travel down the nickel tapes to the delay wire, causing a torsional stress in the wire. In this manner, longitudinal-mode waves are converted into torsional-mode waves. The latter are in turn reconverted to longitudinal waves at the other end of the delay wire by the output mode converter.

Electrical signals in and out of a torsional-mode line are identical to those found in the simple delay line. The mode converters simply change the nature of the strain pulses on the delay wire.

Peripheral Equipment

The information in a delay-line memory is volatile; it must be continually processed by circulating through a closed delay loop. In addition, as delay lines of this type have from 40- to 60-db attenuation, amplification is necessary. Thus, a certain amount of circuitry must be associated with each line. A sense amplifier, a read/write control, a clocking circuit, and a write driver are required. Fortunately, however, the addressing and buffer storage units can serve a large array of delay lines.

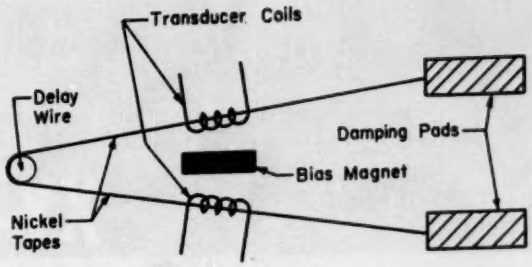


FIG. 3. MODE CONVERTER for developing torsional-mode strain. Longitudinal-mode strain in the tape causes torsion in the delay wire.

Memory Configuration

The memory configuration depends on the application. A single delay-line gives serial/serial operation, while several lines ganged together provide serial/parallel operation. The two configurations are analogous to single-track or multiple-track tape recorders.

Memory control and addressing schemes also depend on the application. The basic methods used with drum or disc storage are applicable. In most cases the average access time of the line is one-half the delay time. The worst-case access time is equal to the delay time of the line (usually 1 to 5 milliseconds). If very long delay-lines are used and short access-times are desired, short delay-lines can be used as a buffer memory between the main storage unit and the arithmetic unit.

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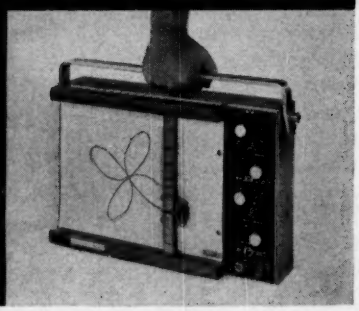

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Measurement of Mean Temperature in a Duct

R. V. DeLEO, F. D. WERNER, and F. W. HAGEN
Rosemount Engineering Company

When fluid flows in a pipe or duct, there is a radial velocity gradient. If the wall temperature is not the same as the fluid temperature, there also will be a radial temperature gradient. The mean or average temperature is not the temperature at the center and the center is not the best place to locate a temperature sensor. Here is how to calculate the best location for a sensor in a long straight pipe.

WHEN FLUID flows through a duct or pipe there may be a temperature gradient across the duct. The average temperature of gases or liquids flowing in the duct is most often desired. It is possible to locate a temperature sensor in a duct so that it experiences the desired mean temperature, but it may require some calculations and assumptions because of the velocity and temperature distribution across the duct.

For long, well insulated ducts, the temperature of the fluid across the duct finally becomes uniform and, of course, a measurement at any point is then satisfactory. The present discussion, however, is concerned with situations where the wall of the duct is hotter or cooler than the fluid flowing through. Here the best location must be calculated or established experimentally.

The factors that must be considered include (1) change in fluid density across the duct, (2) velocity distribution across the pipe, and (3) temperature differential between pipe wall and centerline of flow.

TERMINOLOGY

$P_r = C_p\mu/k$ = Prandtl Number
C_p = specific heat at constant pressure
μ = viscosity
k = thermal conductivity
V = velocity
T = fluid temperature
ρ = fluid density
T_w = wall temperature
T_c = fluid temperature at center line
T_a = average temperature
r = radius of pipe

The average temperature is defined by:

$$T_a = \frac{\int T\rho V dA}{\int \rho V dA} \quad (1)$$

For straight ducts, the pressure across any cross section of the duct is essentially constant and, if the range of temperature ($T_c - T_w$) for the fluid is small, ρ can be considered constant. Thus, for small temperature differentials, equation (1) can be written:

$$T_a \cong \frac{\int TV dA}{\int V dA} \quad (2)$$

For flow of gases in a round pipe, it frequently is possible to calculate the best location for a temperature sensor. When Prandtl number is unity and temperature differentials are small, the velocity distribution and the temperature distribution are identical. Fortunately, Prandtl number is near to unity for gases and this simplifying approximation can be made. Two flow conditions can be distinguished.—(1) those involving fluids at high Reynolds number and (2) those at low Reynolds number.

Long Straight Pipe at High Reynolds Number

In a long straight pipe, if the Reynolds number referred to the pipe diameter is greater than about 6,000, and if the pipe is straight at least 50 diameters upstream from the sensor, the flow at the sensor can be assumed to be "fully developed turbulent flow." This means that the turbulent boundary layer has developed in thickness until it completely fills the pipe. Curve 1 in Fig. 1 shows the velocity distribution for this condition, regardless of the pipe diameter. The same curve applies to temperature distribution when $Pr = 1$ and when T_w has remained approximately constant for at least 50 pipe diameters upstream from the sensor.

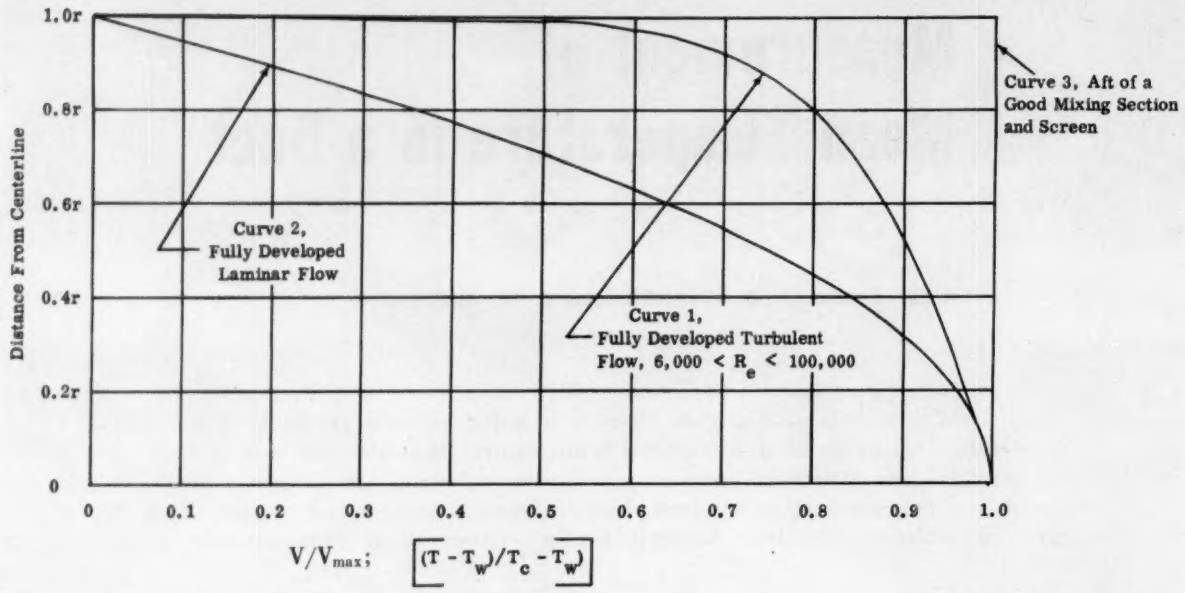

FIG. 1. VELOCITY and temperature distributions in fully developed flow in a pipe. (gases with Pr = 1.0)

For this condition the integration indicated by equation (2) gives the ideal temperature sensor locations, shown in Table 1 when 1, 2, 3, 4, or 5 sensors are used for obtaining the average temperature. For more than 1 sensor the final result is, of course, the mean of the various indicated temperatures.

The preceding assumed no angular variations around the pipe. If it cannot be assumed that there is no angular temperature variation, then it is necessary to divide the cross-section of the pipe into pie-shaped segments and to install additional sensors in each of the segments. For example, using 6 temperature sensors, one might choose to divide the pipe into three 120° segments and to install two sensors in each segment at the radial distances given in Table 1. An alternative might be to divide the pipe into two segments of 180° and to install three sensors in each segment radially according to Table 1, or to divide the pipe into six segments and use the single-sensor radius. Which of these choices is best for a given installation and a given number of sensors must be estimated according to the severity of the angular temperature distribution.

Long Straight Pipe at Low Reynolds Number

If the Reynolds number referred to the pipe diameter is less than 2,000, and if the pipe has a smooth inlet flow condition with the sensor located at least 60 diameters downstream from the inlet, the Reynolds number is too low for turbulence but the boundary layer completely fills the pipe. The flow is called "fully developed laminar flow." The velocity distribution is now given by curve 2 in Figure 1, and the sensor distribution is given in Table 2.

Between the Reynolds number for fully developed turbulent flow and for fully developed laminar flow, one generally cannot be certain whether the flow will be laminar or turbulent. Where practical, the most accurate results are obtained by using a screen or turbulent mixing, as will be discussed.

Errors When Measured at Center

In order to indicate the approximate errors which result if the proper sensor location is not used, one can consider typical cases of flow of gases in pipes with moderate temperature variations (Pr = 1 and ρ nearly constant). Note that the error is important only when the wall is different from the mean temperature. If we assume that the wall is 10° below the mean temperature, a sensor at the centerline will read 5° above the mean temperature for fully developed laminar flow, and 2° above for fully developed turbulent flow.

Flow of Liquids

Prandtl number for liquids usually is much different from unity. Molten metals are commonly 0.003 to 0.03, and most other liquids are above 2.0. Oil can be as high as 50,000 or 100,000 because of high viscosity. Unlike gases, Prandtl number for liquids varies considerably with temperature.

This greatly complicates evaluating equation (1) or (2) because the temperature distribution is much more complex, even for round pipes. Where the variation of T and V can be calculated from available theory (as given in text books such as reference 1 or 2 or from the heat transfer literature), equation (1) or (2) can be evaluated analytically. Otherwise it is necessary to resort to a detailed survey of the temperature and velocity distribution of the actual flow and to use numerical integration, as discussed next.

When the Prandtl number is very high, there is a marked tendency for the temperature to be approximately uniform over most of the center area, with a high temperature gradient near the wall. Very low Prandtl number gives the opposite effect. Thus, it is

TABLE 1—RADIAL POSITIONS FOR CENTER OF SENSOR, FOR FULLY DEVELOPED TURBULENT FLOW (PR = 1.0)

NUMBER of SENSORS	DISTANCES FROM CENTERLINE (Fraction of a Radius)
1	0.72
2	0.46, 0.86
3	0.37, 0.67, 0.91
4	0.34, 0.57, 0.75, 0.93
5	0.27, 0.47, 0.70, 0.80, 0.94

TABLE 2—RADIAL POSITIONS FOR CENTER OF SENSOR, FOR FULLY DEVELOPED LAMINAR FLOW (PR = 1.0)

NUMBER of SENSORS	DISTANCES FROM CENTERLINE (Fraction of a Radius)
1	0.58
2	0.37, 0.73
3	0.30, 0.54, 0.78
4	0.26, 0.46, 0.62, 0.82
5	0.23, 0.41, 0.54, 0.67, 0.84

particularly erroneous to measure the temperature at the center of a circular pipe for molten metals, and relatively accurate for viscous liquids such as lubricating oil.

Downsteam of Screens, Elbows, Pumps, and other Disturbances

Immediately downstream of various disturbances to the flow, it is difficult to predict the velocity and temperature distribution with accuracy for gas flow. When the fluid is a liquid, the analytical approach is even more complex. Therefore, it is usually impractical to establish the most logical positions for temperature sensors by calculations where disturbances exist.

An experimental procedure is to measure the velocity distribution with an elaborate pitot and static pressure survey, and to measure the temperature distribution so that the area can be divided up into zones or increments of area dA, and thereby permit a numerical integration to be carried out per equation (1) or (2).

When accurate work is necessary downstream of obstacles and the experimental procedure is impractical, and if a small amount of pressure drop can be tolerated, a special installation can be used. This consists of creating violent turbulent mixing in a section of the pipe to substantially eliminate radial temperature gradients immediately downstream of the mixing zone. When this is done, temperature can be measured at any convenient radial position regardless of the velocity distribution. Farther downstream, temperature gradients will return as the flow tends back toward fully developed turbulent or laminar pipe flow. Screens can be installed just ahead of or behind the temperature sensor if it is necessary to suppress the violent turbulence (references 3 and 4). For screens, good performance is obtained when the pressure drop through the screen is 3 q or greater, where q is defined as $0.5\rho V^2$.

Violent turbulent mixing can be accomplished in a variety of ways, such as blades protruding into the flow at various angles and positions so as to disturb the flow as much as possible.

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WESCON—1961 *continued from page* 1641

second time interval meter, which, said company spokesmen, offers five times higher resolution than anything else available.

Hewlett-Packard's big booth featured the first showing of the 5844 Waveform Measurement System for semiconductor testing, simultaneously measuring four parameters. Also on view was the 5854 Frequency Measuring System, with accuracy of up to five parts in 10^{10}.

Non-Linear Systems showed for the first time its CS-2 Calibration Console, for calibration of ac and dc digital voltmeters, ratiometers and ohmmeters. Consolidated Electrodynamics Corporation displayed the counter portion of its new 24-510 Radiflo Leak Detector.

The growing interest in **fiber optics** was reflected in several exhibits. General Dynamics/Electronics showed what it calls the first page-width fiber-optic cathode-ray tube. The Charactron shaped-beam tube uses an optic strip 8½" x ½" to display up to 64 characters.

American Optical Company also displayed a fiber-optic cathode-ray tube and its Fiberscope image and light transmitters, flexible tubing which allows seeing around corners. Applications include dental probes, quality control inspection and signature scrambling. The image transmitter has over 5-million fibers per square inch.

Data Handling and Display equipment included the first showing of the Ampex FR 100C general purpose data recorder. Ampex also showed—but is not offering for sale—a wideband 4-Mc loop recorder which sounds like a jet taking off as it winds up to move tape at 1500 inches per second.

The Mincom Division of 3-M showed off its Track-lok module which provides automatic electronic skew correction, overcoming timing errors found between tracks in multiplex track recordings.

Brush Instruments showed its Mark 200 Recorder, a direct writing system featuring forced fluid writing, position feedback control, and direct rectilinear presentation.

General Dynamics/Electronics had on the floor its SC-1090 Direct View Display, an off-the-shelf unit featuring high legibility on a 19-inch shaped-beam Charactron Tube. The company says the unit will sell for around $25,000 and will be available on six-month delivery.

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Provides wide temperature range . . . the FLĀMON Detector can be used in ambient temperatures from −20 to 150°F. Flame-sensing element withstands temperatures up to 500°F.

Allows easy inspection . . . quick-disconnect, keyhole mounting simplifies checking of lens condition and detector alignment.

Simple, solid-state circuitry . . . the FLĀMON Detector unit contains only 10 components.

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A 162-1

Instruments and controls for power and process

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Thermocouple Calibration

THERMOCOUPLES are calibrated by the National Bureau of Standards (Fig. 1) over the temperature range of −190 to +1100° C.[1] Also thermocouple materials—wires of various compositions—are calibrated to determine the voltages they produce when fused to a standard platinum wire. Occasionally, the accuracy of a potentiometer used in thermoelectric measurements will be determined. Samples of freezing-point standards—aluminum, copper, lead, zinc, and tin—also are made available on a fee basis.[2] These standards provide fixed points against which thermocouples can be calibrated in outside laboratories.

Comparison Calibration

The comparison of base metal and platinum thermocouples with the standard platinum *versus* platinum and 10-percent-rhodium thermocouple maintained by the Bureau is performed over the range of 50 to 1100° C. When individual thermocouple wires are being tested, one or more of the test wires are fused to a length of the standard platinum wire, and a standard platinum thermocouple is fused to this junction to provide a basis for comparison. When complete thermocouples are being tested, a common junction is made between one or more test thermocouples (Fig. 2) and the standard thermocouple. The bundle of thermocouples, each insulated by a length of 2-hole porcelain tubing, is inserted into a closed-end porcelain protection tube which is placed in an electrically-heated tube furnace. The emf of the standard and each test wire or thermocouple is determined at a number of preselected temperatures, usually at intervals of 100° C.

When more than four thermocouples are run concurrently, the respective emf's are determined manually through the use of two potentiometers, one which measures the emf of the standard and one which measures each test thermocouple individually. If no more than 4 thermocouples are run at one time, a semi-automatic thermocouple comparator (Fig. 3) records the emf difference between each thermocouple and the standard on a strip chart as a function of temperature, as determined by the standard thermocouple.

Calibration in Liquid Baths

When base-metal thermocouples are to be calibrated at low temperatures, they are compared with platinum resistance thermometers in a variety of liquid media.

At the lower limit of calibration, about −190° C,

FIG. 1. CONTROL PANEL for thermocouple calibration at NBS. Platinum thermocouples are calibrated against platinum resistance thermometers at 419.5°C and 630.5°C. Upper portion of this panel contains the furnace control equipment.

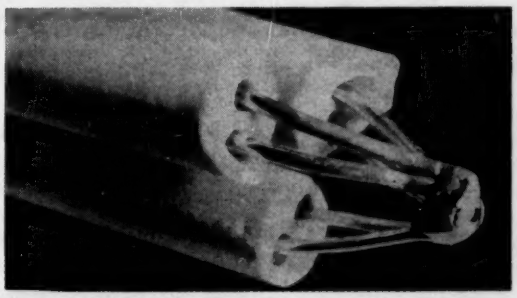


FIG. 2. CLOSE-UP VIEW of 3 thermocouples fused together for calibration. One thermocouple is a reference standard; the other two are to be calibrated.

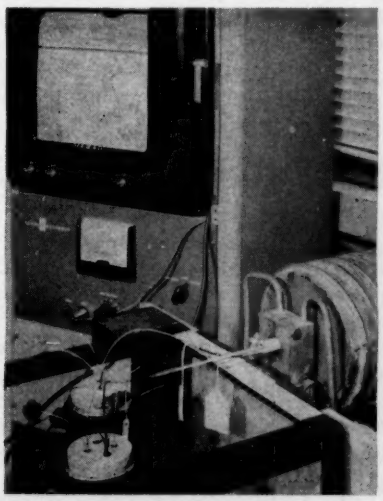


FIG. 3. APPARATUS used by the National Bureau of Standards for thermocouple calibration over the range of 50 to 1100°C. A bundle of several thermocouples is heated in an electric furnace (right), and the reference junctions are maintained at 0°C in an ice-filled Dewar (lower left). As the temperature increases, the emf values for each thermocouple are recorded.

Table 1. *Summary of methods and accuracies obtainable in calibrating thermocouples.*

Type of thermocouple	Methods of calibration	Temperature range	Calibration points	Accuracy at observed points	Method of interpolating	Uncertainty in interpolated values
		°C		°C		°C
Platinum versus platinum-10-percent-rhodium.	International Temperature Scale (fixed points).	630.5 to 1,063.0	Freezing point of Sb, Ag, and Au.	0.2	Equation: $E=a+bt+ct^2$	0.3
Platinum versus platinum-rhodium.[a]	Fixed points	0 to 1,450	Freezing point of Zn, Sb, Ag, and Au.	.2	Difference curve from reference table	0.5 to 1,100 and 2 at 1,450.
	NBS Standard Samples, fixed points.	0 to 1,450	Freezing point of Sn, Zn, Al, and Cu.	.2	do	.5 to 1,100 and 2 at 1,450.
	Comparison with standard thermocouple.	0 to 1,450	About every 100° C	.3	do	.5 to 1,100 and 2 at 1,450.
	do	0 to 1,450	About 600° and 1,100° C (or more points).	.3	do	1 to 1,100 and 3 at 1,450.
Chromel-Alumel	Comparison with standard thermocouple.[a]	0 to 1,100	About every 100° C	.5	Linear	1
	do	0 to 1,100	About 300°, 800°, and 1,100° C (or more points).	.5	Difference curve from reference table.	2
	Comparison with standard resistance thermometer [b] or at fixed points.	0 to 350	About every 100° C	.1	do	0.5
	Comparison with standard resistance thermometer.[b]	0 to −190	About every 50° C	.1	do	.5
Iron-constantan	Comparison with standard thermocouple.[a]	0 to 760	About every 100° C	.5	Linear	1
	do	0 to 760	About 100°, 300°, 500°, and 750° C	.5	Difference curve from reference table	1
	Comparison with standard resistance thermometer [b] or at fixed points.	0 to 350	About every 100° C	.1	do	0.5
	Comparison with standard resistance thermometer.[b]	0 to −190	About every 60° C	.1	do	.5
Copper-constantan	Comparison with standard resistance thermometer [b] or at fixed points.	0 to 300	About every 100° C	.1	Equation: $e=at+bt^2+ct^3$ or difference curve from reference table.	.2
	Comparison with standard resistance thermometer.[b]	0 to 100	About 50° and 100° C	.05	Equation: $e=at+bt^2$ or difference curve from reference table.	.1
	Fixed points	0 to 100	Boiling point of water	.05	Equation: $e=at+0.04t^2$	.2
	Comparison with standard resistance thermometer.[b]	0 to −190	About every 60° C	.1	Equation: $e=at+bt^2+ct^3$ or difference curve from reference table.	.2
	Fixed points	0 to −190	Sublimation point of CO_2 and boiling point of O_2.	.1	Difference curve from reference table.	.3

[a] Either 10- or 13-percent rhodium. [b] In stirred liquid bath.

the thermocouple is placed in an open Dewar filled with liquid nitrogen. At a slightly higher temperature, approximately —183° C, liquid oxygen is used. From —140° to slightly below 0° C an automatically controlled cryostat[6] is used to provide a variety of temperatures. At 0°C all test thermocouples produce no emf, as the reference junction also is maintained at 0° C. For values slightly above 0° C, to just below the boiling point, water is used as the heating liquid.

Comparison measurements over the range of 100 to 300° C are made in two different oil baths, one is used between 100 and 200° C and the other from 200 to 300° C.[7] A stirred bath of liquid tin is used for temperatures up to 538° C, the upper limit of the liquid-bath technique.

Accuracy

The accuracy of a particular calibration depends on the material being tested, the type of calibration made (fixed point or comparison), and the range over which a temperature-emf relationship is established. Accuracies range from 0.05° C for a copper-constantan thermocouple compared with a standard resistance thermometer, to 0.5° C for a Chromel-Alumel thermocouple compared against a standard thermocouple. Of course, the uncertainty of interpolated values is greater than that at fixed points, and this uncertainty increases as the difference from the nearest known point increases (see Table 1).

A certificate is prepared and sent to the user for each thermocouple that is calibrated. This certificate lists the emf developed by the thermocouple over a specified range of temperatures. If the thermocouple is of platinum versus platinum-10%-rhodium and has been calibrated against fixed points, the equation for interpolation between 630.5 and 1063° C also is given.

Thermocouple Research

The Bureau is conducting a variety of research programs designed to increase the useful range of thermocouples, and to improve upon the procedures used in present calibrations.

Experiments with a number of combinations, including iridium versus iridium-rhodium, tungsten versus rhenium, and others, may eventually extend the upper limit of thermocouple measurements to above 2000° C.

References

1. "Test fee schedules of the National Bureau of Standards," page 17, 1959. Available from the Office of Technical Information, NBS, Washington 25, D. C. Copies of 2, 3, 4, 5 and 7 below may be ordered from the Superintendent of documents, U. S. Government Printing Office, Washington 25, D. C.
2. "Standard Materials Issued by the National Bureau of Standards," NBS Circular 552 (35 cents).
3. "Reference Tables for Thermocouples," NBS Circular 561 (55 cents).
4. "Methods of Testing Thermocouples and Thermocouple Materials," NBS Circular 590 (20 cents).
5. Stimson, J. F., "The International Practical Temperature Scale of 1948," Journal of Research NBS (to be published).
6. "Temperature, its Measurement and Control in Science and Industry," Vol. 1, page 206, Reinhold Pub. Corp., 1941.
7. "Calibration of Liquid-in-Glass Thermometers," NBS Circular 600 (20 cents).

Logical Design of Control Systems

WILLIAM J. KERCHNER, JR., Gilbert Associates, Inc.

Control and protection circuits with interlocking features lend themselves to representation by functional diagrams. Analysis by symbolic-logic techniques permits simplification of circuitry and saving in equipment.

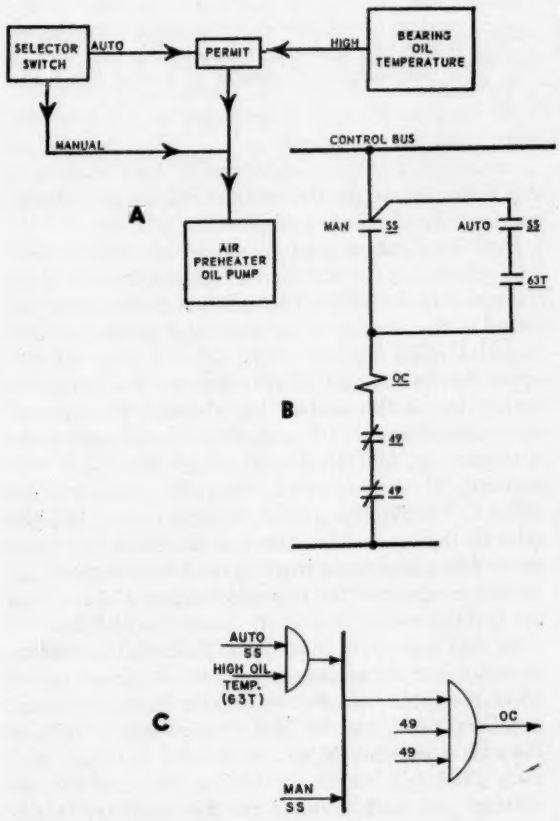


FIG. 1. CONTROL of an air preheater oil pump by bearing oil temperature. A is functional diagram; B is schematic. C is symbolic-logic schematic.

CONCEPTION of a control system begins with a study of the characteristics of the equipment to be controlled, the extent of remote operation, the operation cycle, the degree of data logging and control, etc. At this point, the design engineer is faced with the problem of transferring information about his conceived control system to others. An effective means of doing this is by use of a functional diagram.

This type of diagram defines the *function* of a particular control system without becoming involved with details of circuitry at the early stage of system design. All major items necessary to understand the operation of a control system are represented by blocks connected together by arrowed lines to indicate the path of control. For example, assume it is required that the oil pump for an oil preheater start and stop automatically in response to high oil temperature of the air preheater bearings; also it is desired to provide for manual control of the oil pump. Fig. 1A is the functional diagram for this situation. Fig. 1B, the schematic, indicates that when the selector switch (SS) is placed in the manual position, the oil pump will start and run continuously. In A this is shown by the arrowed line marked MANUAL, connecting the selector switch and oil pump blocks. In B, when the selector switch (SS) is placed in the manual position to close contact MAN, a circuit will be completed through the motor-starter operating coil (OC) and motor overload relay contacts (49) to both sides of the control bus.

The diagrams also indicate that when the selector switch is placed in the automatic position, the oil pump will start and stop in accordance with bearing oil temperature (63T).

Fig. 1C shows a symbolic-logic representation of Fig. 1B.

Turbine Generator

In a power plant, devices are provided to protect the turbine-generator against internal and external abnormal conditions. Generally, these protective devices energize a *main trip solenoid* which will close all turbine valves and "trip" the generator from the system. This requires a complex system of both electrical and mechanical interlocks, a few of which are shown in the functional diagram, Fig.

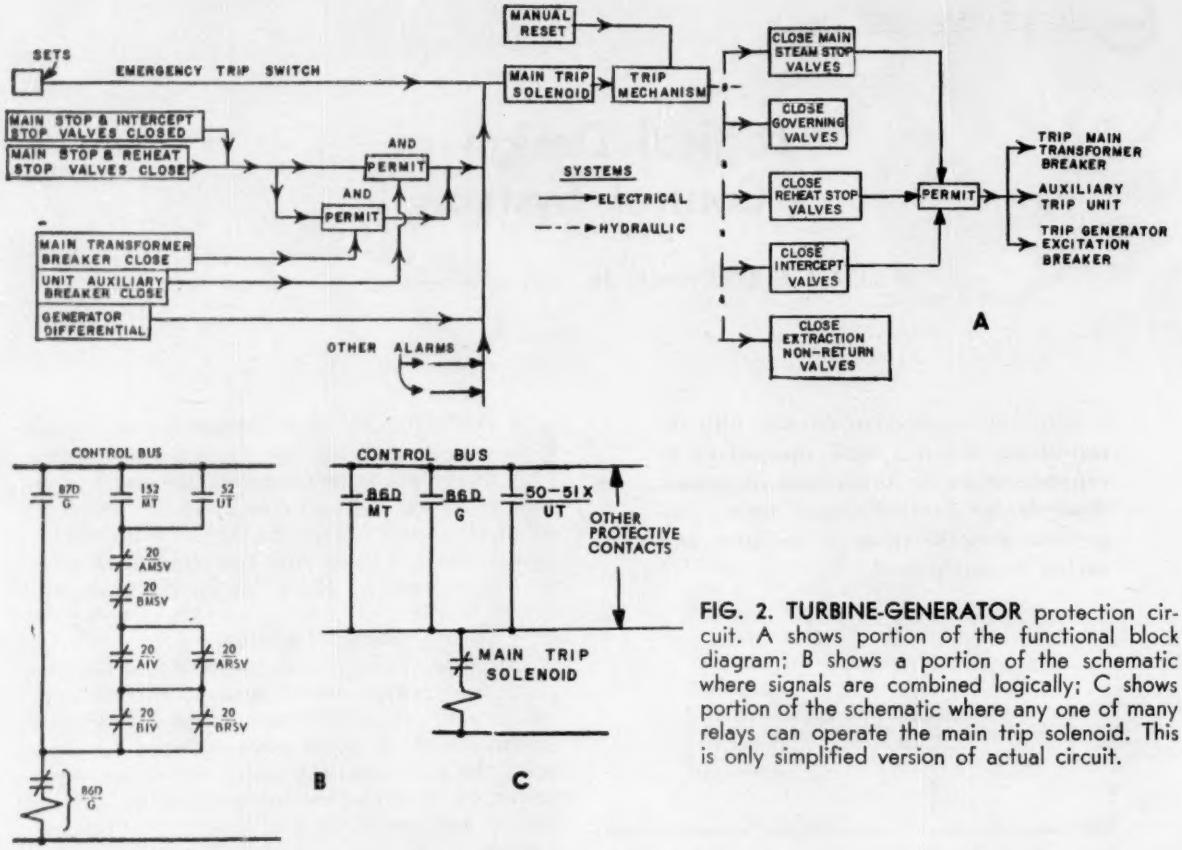


FIG. 2. TURBINE-GENERATOR protection circuit. A shows portion of the functional block diagram; B shows a portion of the schematic where signals are combined logically; C shows portion of the schematic where any one of many relays can operate the main trip solenoid. This is only simplified version of actual circuit.

2A. Here the main-trip-solenoid (top center), trip mechanism, turbine valves and PERMIT junctions are represented by blocks. The arrowed lines indicate the sequence of operation from its initiation by the turbine protective devices to shutting down the turbine by closing the turbine valves. Solid arrowed lines indicate an electrical signal; dotted arrowed lines, indicate a mechanical linkage, and dash-dot arrowed lines a hydraulic circuit. The following examples illustrate the sequence of operation to shut down the turbine-generator unit for two abnormal conditions:

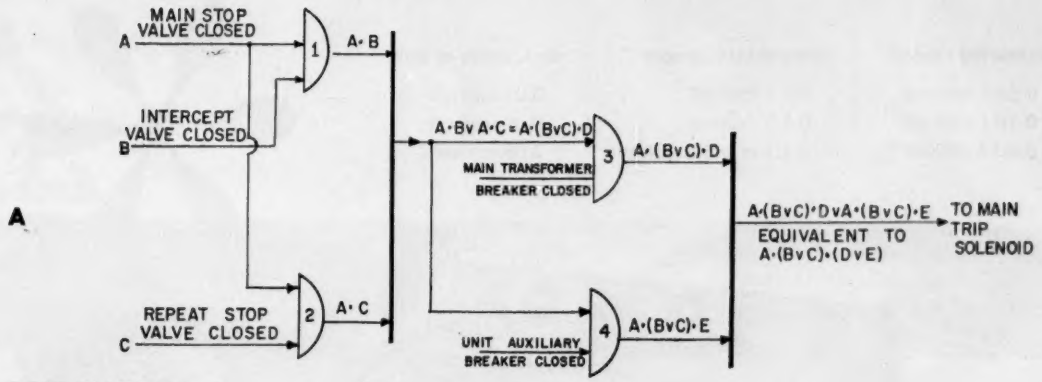
1. Assume an electrical fault within the generator windings has resulted in the operation of a *generator protective differential relay* (lower left box in Fig. 2A). This will energize the main trip solenoid, which (through the trip mechanism) will close all turbine valves (hydraulically) and shut down the unit. When the main steam stop and reheat stop or intercept turbine valves have closed, the PERMIT block shown at the extreme right will attempt to trip the main-transformer, unit-auxiliary-transformer and generator-excitation circuit breakers. (In this particular sequence the circuit breakers were already tripped by operation of the generator protective differential relays.)

2. Assume an abnormal condition exists which closes the turbine main stop and intercept valves while either the main transformer or the unit auxiliary circuit breaker is closed. The combination of these conditions passes a signal through one of the upper-left PERMIT blocks to energize the main trip solenoid. Again the turbine valves are closed, tripping the circuit breakers.

Fig. 2B shows a portion of the electrical interlock schematic. In the first example discussed, an electrical fault within the generator windings resulted in the closing of the generator protective differential relay contact (87D/G), which is at the upper left in Fig. 2B. This completes the circuit to both sides of the control bus through the operating coil and contact of an auxiliary hand-reset lockout relay (86D/G). When device 86D/G is energized, it will close a normally-open contact (86D/G) in Fig. 2C to complete the circuit to both sides of the control bus through the main trip solenoid. When the main trip solenoid is energized, its armature operates the trip mechanism which closes the turbine valves and shuts down the turbine.

In the second example, an abnormal condition closed the turbine main stop and intercept valves while the main transformer or unit auxiliary circuit breakers are closed. This completed a circuit through a network of circuit-breaker auxiliary contacts (152/MT, or 52/UT in Fig. 2B) and the operating coil and contact of the auxiliary hand-reset lockout relay (86D/G). As in the first example, when device 86D/G is energized, its normally-open contact (86D/G in Fig. 2C) will close to complete the circuit through the main trip solenoid. The remainder of the operational sequence is the same as described.

These yes/no type of control decisions lend themselves to illustration by symbolic-logic diagrams.



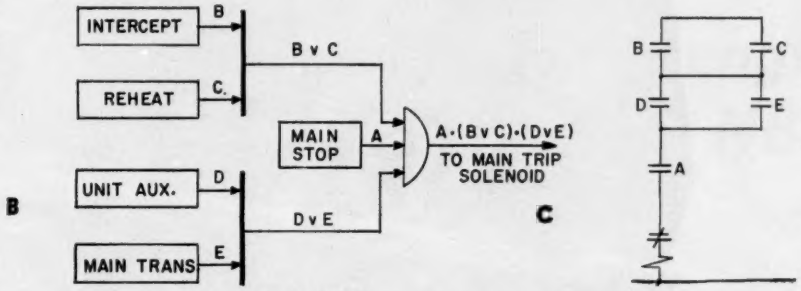


FIG. 3. LOGIC DIAGRAM of a portion of the protection circuit is shown at top. Bottom left shows the simplified circuit that produces the same output. Bottom right shows the switch contacts for the logic diagram at lower left.

Fig. 3A is a logic diagram for the network surrounding the two PERMIT blocks at upper left in Fig. 2A. The main-stop-valve-closed signal is labeled A; the intercept-valve-closed signal is B. When both these signals occur there is an output (A•B) from AND gate number 1. The reheat-stop-valve signal is C. When either A and B, or A and C exist, the PERMIT boxes (upper left in Fig. 2A) are enabled. This is shown in Fig. 3A by feeding an OR gate with the outputs of the first two AND gates. The OR-gate output is A•B υ A•C, which is the same as saying A•(B υ C).

AND gates 3 and 4 represent the PERMIT blocks at upper left in Fig. 2A. The main-transformer-breaker-close signal is D; the unit-auxiliary-breaker-close signal is E. The No. 3 AND-gate output is thus A•(B υ C)•D; No. 4 AND-gate output is A•(B υ C)•E. The output of either AND gate can trip the main solenoid. This requires an OR gate, which produces an output (A•B υ C)•D υ A•(B υ C)•E. Either this output, or that from any other of the abnormal initiating conditions can operate the main trip solenoid.

The combined output signal from the PERMIT blocks that is developed above contains a common term, A•(B υ C). This can be factored out. The equivalent logic expression becomes A•(B υ C)•(D υ E). Each of these three terms can be developed separately, then brought to an AND gate to provide the equivalent signal, as shown in Fig. 3B. Fig. 3B uses 2 OR gates and 1 AND gate to get the same output signal delivered by 2 OR gates and 4 AND gates in Fig. 3A. The use of logic analysis eliminated three AND gates, showing the value of logic techniques.

The actual protective circuit was more complicated than that shown in Fig. 3, and actually had eight inputs to the auxiliary hand-reset lockout relay coil (86 D/G) on the main trip solenoid. These eight (Fig. 4) were (A) right main stop, (B) left main stop, (C) right intercept, (E) right reheat, (D) left intercept, (F) left reheat, (G) main transformer, (H) unit auxiliary. The original control circuit was represented by the equation shown at the top left in Fig. 4. By symbolic-logic analysis of this equation, the simplified equation shown in Fig. 4 was developed, and implemented as shown at the right in Fig. 4. Considerable savings thus were effected by symbolic-logic analysis of the control circuits.

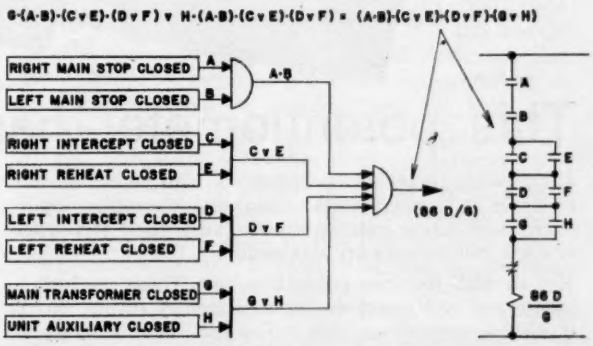


FIG. 4. ACTUAL CIRCUIT had eight inputs controlling main trip solenoid (86D/G).

Acknowledgement

Figs. 1A, 1B, and 2, and portions of this paper, were abstracted from the paper "Logical Commissioning of Control Systems," by Wm. J. Kerchner, Jr., and Robert M. Maust, Gilbert Associates, Inc., presented at ISA Third Annual Power Symposium, San Francisco State College.

Measuring ranges	Compensator ranges	Max. limits of error
0-16.1 millivolt	0-1.1 millivolt	0.01 millivolt
0-16.1 millivolt	0-5.5 millivolt	0.02 millivolt
0-80.5 millivolt	0-1.1 or 0-5.5 millivolt	0.05 millivolt

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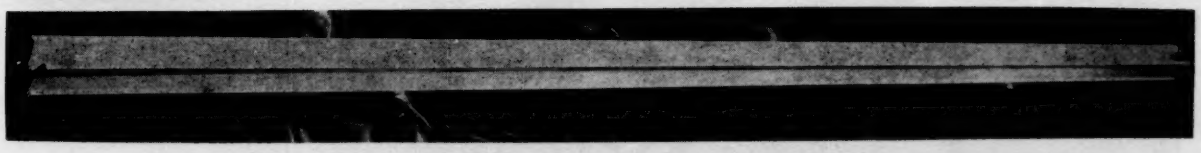

FIG. 1. U. S. National prototype meter 27.

Calibration of Line Standards of Length and Measuring Tapes at NBS

LEWIS V. JUDSON National Bureau of Standards

THE Bureau receives many requests from scientists, industry, and governmental agencies to calibrate line standards of length and measuring tapes.

The primary standard of length in the United States was* the National Prototype Meter 27 (Fig. 1), which is identical in form and material with the International Prototype Meter deposited at the International Bureau of Weights and Measures at Sevres, near Paris, and also with the other national prototype meters distributed in 1889 in accordance with the treaty known as the Convention of the Meter, dated May 20, 1875. Except for expressing data in feet derived from and published as a result of geodetic surveys within the United States (for which the relation 1 foot = 1200/3937 meter continues to be used) the yard in the United States is defined in terms of the meter by the relation

1 yard = 0.9144 meter.

At the Bureau there are secondary and laboratory length standards of various materials, sizes, and degrees of precision. Their lengths are known in terms of the prototype meter. These secondary and laboratory standards are used in the calibration work done by the Bureau.

Facilities for Calibrating Line Standards of Length

For the calibration of line standards of length the most precise measurements now being made at the Bureau are on its 1-m longitudinal comparator (Fig. 2). It is especially suited for the calibration of the subintervals of a bar, using one of the several methods that have been developed. Although this comparator is nominally a 1-m comparator, it is readily adaptable for standardizing 48″ bars, and can be used for calibrating even longer bars.

For comparing two bars with an accuracy not better than 1 micron (0.001 mm or 0.00004″) a simple transverse comparator with no thermal insulation is commonly used. In this instrument the bars are mounted parallel to each other, and the carriage

*Subsequent to the publication of NBS Monograph 15, the Eleventh General (International) Conference on Weights and Measures redefined the meter in terms of the orange-red radiation in vacuum of krypton 86 corresponding to the unperturbed transition between the $2p_{10}$ and $5d_5$ levels as follows:

1 meter = 1,650,763.63 wavelengths

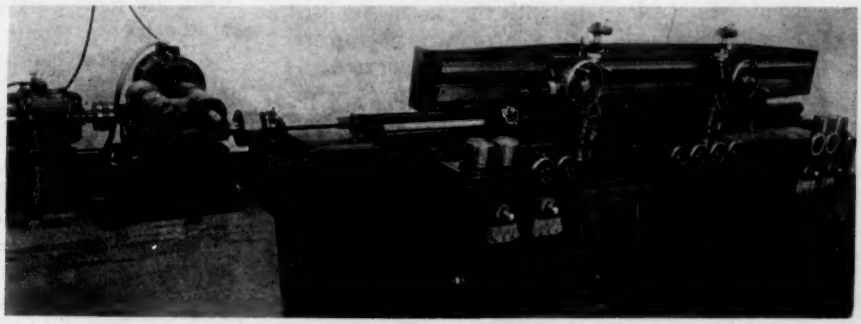

FIG. 2. LONGITUDINAL comparator.

Abstracts from NBS Monograph 15.

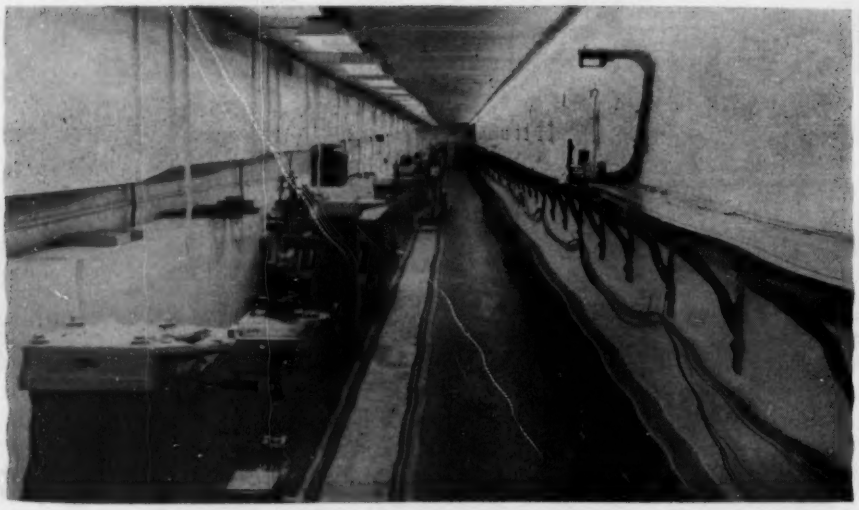

FIG. 3. TAPE calibration laboratory.

supporting the two bars moves back and forth in a direction perpendicular to a line parallel to the axis of each of the two bars. The micrometer microscopes are not moved during a comparison with this transverse comparator.

Short bars and small scales are often more conveniently calibrated by means of a linear dividing engine having two microscopes conveniently mounted so that they can be focused on the bars mounted on the longitudinally moving carriage. The instrument is then, in effect, a longitudinal comparator.

Facilities for Calibrating Measurng Tapes

At the Bureau there is a temperature-controlled laboratory about 212′ long (Fig. 3). Two installations have been made in this laboratory. One is a 200′ steel bench for calibrating steel tapes used in general surveying and engineering practice, as shown at the right in Fig. 3. The other is a geodetic comparator especially for calibrating the 50-m invar base-line tapes, such as are used by the U. S. Coast and Geodetic Survey. Its use is not limited, however, to a 50-m length. It is shown at the left in Fig. 3.

Steel-Tape Bench

The steel-tape bench has an over-all length of 200′ 1″, a width of 2½″, and a thickness of ¾″, and is constructed of stainless-steel bars approximately 12′ long, with individually lapped and fitted ends.

Comparisons of a tape with the bench standard are ordinarily made with a low-power microscope and a precision steel scale graduated either to 0.01″ or to ½ mm. When unusually high accuracy is required and the character of the graduation lines warrants, comparisons with the bench can be made with a micrometer microscope.

Geodetic Tape Comparator

A 5-m bar, packed in melting ice when measurements are being taken, is the working standard used as the basis of measurements in the geodetic tape comparator. Piers bearing microscopes are spaced 5 m apart for a total length of 50 m. Auxiliary piers 1 m apart, also bearing microscopes, are placed between the 20-m and the 25-m piers. These provide intervals so that the 5-m bar can be standardized by means of a calibrated 1-m bar. By use of a special bracket at the 15-m pier a double pier at the 30-m location, and an additional pier near the 45-m pier, it is possible to mount microscopes at the 50-, 100-, and 150-ft points. In Fig. 4 are shown the 15-m and 50′ microscopes at the extreme left, then the covered trough and carriages for the 5-m bar, immediately beyond that the six piers with their microscopes spaced 1-m apart, and other piers beyond them.

In addition to the basic equipment of the comparator, there is the necessary auxiliary equipment, such as tape clamps, thermometers, etc.

Calibration of Line Standards of Length

The measurement of line standards of length undertaken by the Bureau is classified under the headings of *reference* standards, *working* standards, and *commercial* standards.

A complete calibration includes the determination of the length at a known temperature and also of the expansivity, usually expressed by the average coefficient of linear thermal expansion over a small range of temperature that embraces the temperatures at which the standard is likely to be used. For most work with any standard except one of the highest grade it is sufficient to assume a coefficient of expansion derived from a knowledge of the composition of the materials of which it is made. If the standard is subdivided, a calibration of the subdivisions may also be necessary. The number of intervals that it is advisable to compare will depend on the character of the standard and on the use to which it is to be put. In many cases it is unnecessary to determine the correction for the subdivision; a proportionate part of the errors for the total length may be assumed. Where it is neces-

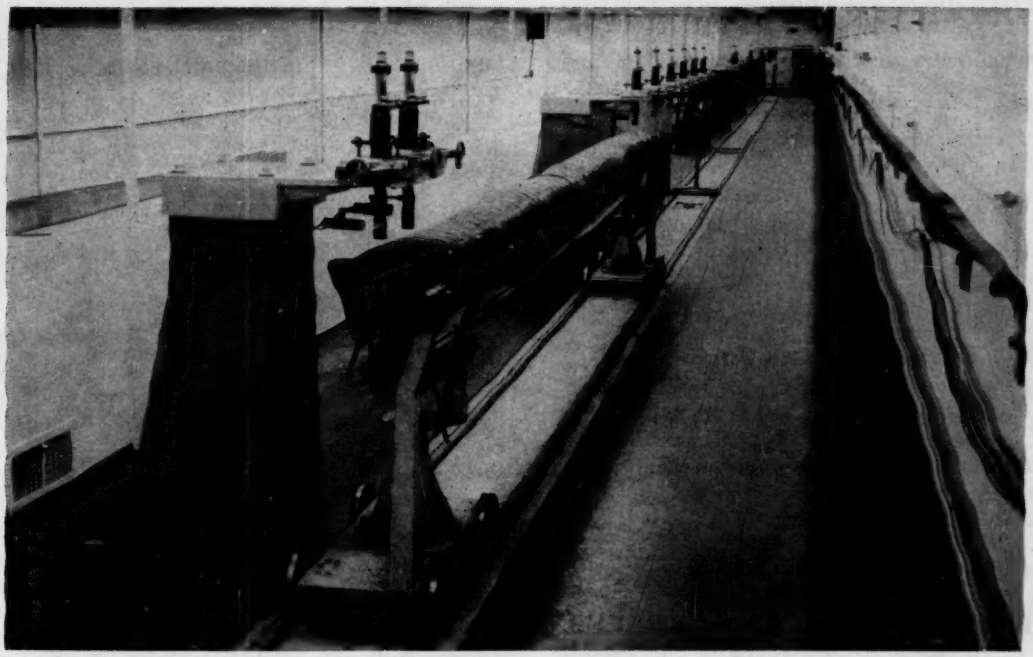

FIG. 4. **TAPE** calibration laboratory showing some details of the geodetic comparator.

sary to measure a greater or less distance than the full length of the standard it is only necessary, in many cases, to test a few subdivisions; for example, any distance in even feet may be accurately measured with a 100′ tape if the corrections are known for the entire length of the tape, for each 10′ subdivision, and for each foot of the first 10′.

It should be noted that while platinum-iridium may be the best material for fundamental length standards, other materials are better suited to the needs of manufacture and industry; for example, steel rules and tapes are better for determining the sizes of steel and iron machine parts and structural members because changes in length with changes in temperature are practically the same in the steel rule or tape as in the steel or iron part being measured.

Metric standards should be graduated to be correct at either 0° or 20°C, the latter temperature being preferred for everyday use because it eliminates to a great extent the question of differences in expansion. In this country, standards in the customary units of yards, feet, and inches are made to be correct at 68°F (20°C).

Requests for calibration to be made by the Bureau should state the use to which the results are to be applied and also the accuracy desired, in order that the tests may be adequate for the end in view, avoiding unecessary labor and expense. Where the highest attainable accuracy is needed, it is sometimes advisable to have the standard verified immediately before and again immediately after the important measurements in order to guard against possible changes due to undetected injury or structural alteration.

Reference Standards

This class includes standards of the highest type suitable for reference standards for makers of precision apparatus and for use in the most exact scientific investigations. One of the best constructions is that conforming to the specifications adopted for the prototype meters by the International Committee on Weights and Measures; but less expensive constructions are sufficient for all but exceptional purposes.

Working Standards

This class includes standards suitable for all ordinary precision work and suitable for the needs of college laboratories, manufacturers of better grades of scientific apparatus, State superintendents of weights and measures, and most scientific work.

Standards of this class are compared with working standards of the Bureau and are certified to 0.001 mm if their quality justifies it.

The owner of a working standard is sometimes justified in having a calibration made at the Bureau, but he may find that a calibration made by the maker or by himself is sufficient if a reference standard is available with which to make the comparison.

Commercial Standards

This class includes flat metal bars graduated along the center of the surface or along one or more edges, with lines less than 0.06 mm (0.0024″) wide. They should be of sufficiently good grade to meet the requirements for drafting, machine work, etc., and to meet the needs of local sealers of weights and measures. It is recommended that those for the use of sealers be graduated in milli-

meters for a distance of 1,010 mm or in 1/32″ for 37″. New meter standards should be accurate to 0.1 mm or better at a temperature of 20°C, and new yard standards should be accurate to 0.005″ at 68°F.

Commercial standards seldom require calibration by the Bureau. Local sealers of weights and measures will usually have their standards calibrated by State officials, and most other users will be justified in relying upon the reputation of the manufacturers, especially if purchase specifications have prescribed the accuracy of the standards.

Calibration of Measuring Tapes

Steel and invar tapes used in surveying, engineering, maufacturing, and construction work are calibrated at the Bureau. Tapes intended for geodetic base-line work require a very accurate calibration; steel tapes used for more routine work can be calibrated to sufficient accuracy, using simpler apparatus and procedures.

Tapes are compared with the steel-tape bench at the Bureau when supported throughout their entire length or when supported at specified points. These comparisons are accurate to the nearest 0.001′ or 0.2 mm. When an accuracy greater than this is necessary, the Bureau is prepared to compare tapes of suitable length on its geodetic-tape comparator.

The standardization of a tape includes the comparison of the total length and of specially designated intervals.

Specification for Standard Steel Tape

A steel tape is considered as standard when it has been calibrated by the Bureau and found to conform to the following specification: It shall be made of a single piece of metal ribbon, and none of the graduations shall be on pieces of solder or on sleeves attached to the tape or wire loops, spring balances, tension handles, or other attachments liable to be detached or changed in shape. The error in the total length of the tape, when supported horizontally throughout its length at the standard temperature of 68°F (20°C) and at standard tension, shall not be more than 0.1″ per 100′ (2 mm per 25 m). The standard tension is 10 lb (4.5 kg) for tapes 25′ to 100′ or from 10 to 30 m in length and 20 lb (9 kg) for tapes longer than 100′ or 30 m.

Certification of Tapes

Tapes conforming to the specification will be certified by the Bureau and a precision seal showing year of standardization will be placed on each tape so certified. For tapes not conforming to the specification a report will be issued but the tapes will not be sealed. The Bureau's serial number on a tape simply signifies that it has been tested by the Bureau and either a certificate or a report issued.

Ordinarily the length of a steel tape is certified or reported by the Bureau to the nearest 0.001′ or 0.0002 m (0.2 mm).

Instructions to Applicants for Calibration

The Bureau will accept for calibration only a standard or an apparatus that is well made and not likely to change excessively. An adequate degree of quality is insisted upon as a prerequisite to acceptance for calibration. Line standards of length should be made of suitable material, such as iron alloy, brass, bronze, platinum alloy, or glass, and should be of a construction and workmanship suitable for the intended accuracy. Poorly divided scales on metal, and scales graduated on wood, plastics, or paper will not be accepted. In general, a linear scale of a grade better than the best machinist's scales will be required for a calibration by the Bureau.

All articles submitted for calibration should be accompanied by a written request. This request should enumerate the articles, giving the identification marks of each, and should state explicitly the nature of the calibration desired, and an approximate valuation of the articles should be stated for use in insuring the return shipment.

The application should state clearly the nature of the calibration desired, namely, the points at which measurements are to be made and the temperature, especially if other than standard, or any other conditions. The most accurate results can be obtained and delays avoided only when such full information is given. It is also desirable that the Bureau be informed as to the conditions under which the apparatus is used and the character of the work for which it is employed.

Special Calibrations

The Bureau will cooperate with scientific investigators, manufacturers of apparatus, and others who need higher precision than is provided in the regular schedules by undertaking special calibrations as far as the regular work of the Bureau will permit.

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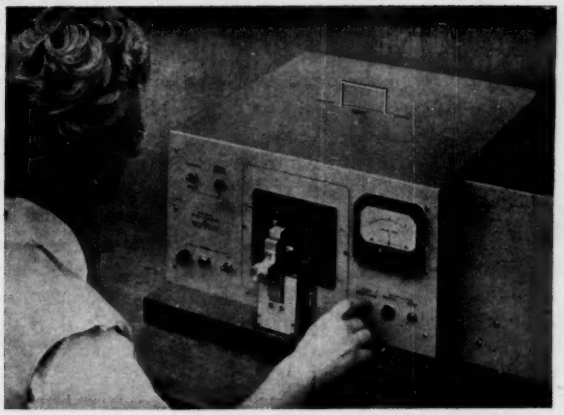


FIG. 1. **HEWLETT-PACKARD** Automatic Meter Calibrator prepares high-accuracy meter scales tailored to individual meter.

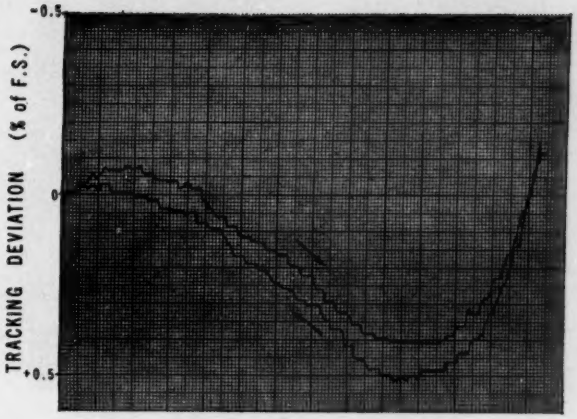


FIG. 2. **RECORD** of tracking deviation.

Servo Calibration of Precision Meters

A specially-developed machine that automatically prepares an individual meter scale for each individual meter provides calibration accuracy of better than 0.25%, and also gives each meter a performance inspection.

BERNARD M. OLIVER, Hewlett-Packard Company

THE BEST d'Arsonval-type movements exhibit some departure from a linear deflection-vs-current characteristic. This occurs because the flux in the airgap is not absolutely uniform due to such factors as variations in the radii of pole faces, centering of pole faces, partial saturation of pole tips, centering of the core, etc. The resulting departure from a linear deflection characteristic is called "tracking deviation."

In many cases the only difference between a meter of greater accuracy and one of lesser accuracy is the degree to which the scale matches the tracking curve of the movement. For simple indicating meters of low accuracy a single, preprinted scale usually is used. For meters of higher accuracy, several preprinted scales may be prepared to take into account the nonlinearities in the deflection-vs-current characteristic of the meters. Thus, for meters having on the order of 2% accuracy, past practice has been to prepare three standard preprinted scales, differing slightly in shape or linearity. The tracking of each movement then is measured at appropriate points and the standard scale selected which best matches the actual deviation. When meters are to be calibrated to an accuracy of 1%, six standard scales are generally required and the selection job is more difficult. For still higher accuracies, the preprinted-scale approach becomes impractical and expensive individually hand-calibrated scales are used. In fact, in many commercial meters the only difference between an expensive meter of 1% or better accuracy and a cheaper, less accurate model is the pains taken in obtaining proper scale fit.

Abstracted from article in *Hewlett-Packard Journal*, Vol. 12, No. 7, March, 1961.

The Meter Calibrator

A machine has been developed at Hewlett-Packard to produce individually-calibrated scales for the precision meters used in H-P instruments, and is in regular production use today. Over and beyond this primary objective, however, the meter calibrator provides a sensitive means of evaluating meter performance. It reveals defects scarcely detectable by more conventional tests and does so without breaking the manufacturers' seal.

The calibrator is shown in Fig. 1. The completely

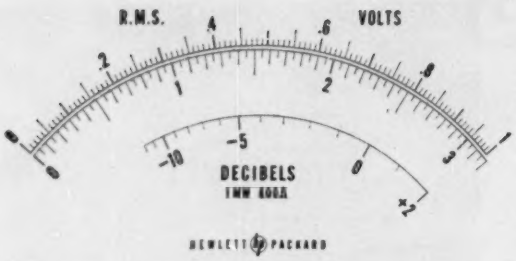


FIG. 3. SCALE produced by calibrator.

assembled meter, in its case but without scale, is placed in a centering fixture. The meter then is supplied a current which, in the absence of tracking deviation, increases linearly from zero to full-scale value. The meter responds to this current and the position of the pointer is tracked optically. Any tracking deviation in the pointer from the linear scale position corresponding to the instantaneous driving current produces an error signal which causes a servo to correct the driving current. At the same time the servo rotates a master scale by a corresponding amount. The servo thus acts to put each point on the master scale at its proper angular position at the time that point is printed. In this way a scale is produced which is everywhere corrected to the particular deflection characteristic of the meter. Scale and meter then are removed from the calibrator and later assembled in a dust-free, controlled-atmosphere hood.

Since the meters as received may not be accurately zero-set, and since the full-scale sensitivity may vary several percent, additional automatic steps were included in the sequence of operation of the calibrator. During an acquisition phase, the machine first electrically picks up the pointer and electrically sets the pointer to the proper zero scale position. It next slews to full-scale position, and sets the full-scale current. Then, as the current is reduced from the full-scale value back to the zero-scale value, the scale is printed. In this way all scales are printed with the proper end-point locations as well as with the proper shape in between. All these operations make use of the same servo system. The entire calibration cycle takes less than one minute so that one machine and one operator can print several hundred meter scales per day. At this rate the cost is comparable to the use of pre-printed scales.

As a check on final performance, the calibrated meters are tested for accuracy at all cardinal points after the meter scale has been assembled onto the movement. These tests are carried out in a standard test set which generates a series of currents having precisely the correct ratios.

Additional Performance Improvements

While the meter calibrator was intended only as a solution to the problem of tracking error, its use has resulted in the elimination of a number of other common meter troubles from production units. As the servo in the calibrator turns to compensate for the tracking deviation, a potentiometer geared to this same shaft delivers a voltage which is at all times proportional to the deviation. By applying this voltage to one axis of an X-Y recorder, and applying a voltage proportional to the meter current to the other axis, an automatic recording is obtained during calibration of the tracking deviation. A recording obtained in this way of a typical healthy meter is shown in Fig. 2. By inspection of such error records, many troubles which might otherwise pass unnoticed can be discovered.

ADDITION OF BRINE USED FOR ION-EXCHANGE PROCESS IS CONTROLLED BY CHANGE IN TANK LEVEL

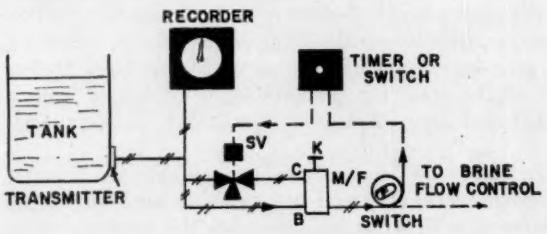
In a batch process used at Gunnar Mines Limited, Uranium City, Saskatchewan, brine is employed for the activation of an ion-exchange column. It is desired to add a given amount of brine to the column. The brine is in a tank.

The problem was solved by using a differential relay to measure the difference in level in the tank. The relay (M/F) receives a pressure signal from a pressure transmitter at *both* its inputs (B and C). At the beginning of an operating cycle, this pressure is locked in at input C, whereas input 3 continues to receive the level signal.

Thus the output of the relay represents a change in level, starting at the time that the pressure is locked into input C.

The pressure is locked in via a 3-way solenoid-valve controlled by a timer or switch.

The relay (M/F) output can be expressed as $T = B - C + K$, where K is a constant adjustable by hand. Any given value of pressure can be made to operate a pressure switch which in turn can operate a brine control valve, etc.

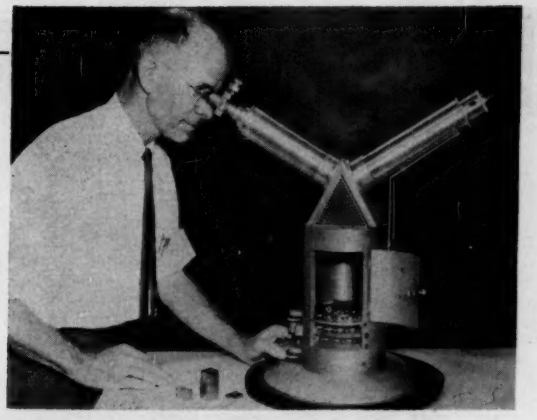


The level in the brine tank is recorded at all times by a recorder.

Equipment used: Moore Products Nullmatic M/F relay, Model 68-1; Nullmatic pressure transmitter, Model 18; any reputable pneumatic level recorder; reset timer; solenoid valve (SV); mercury switch; accessories.

Source: E. J. Kuhlmann, Gunnar Mines, Ltd., Uranium City, Saskatchewan, Canada.

Interferometer For Gage-Block Parallelism



Rapid and convenient measurement of the parallelism of opposite faces of gage blocks is made possible by an interferometer (Fig. 1) designed by J. B. Saunders of the National Bureau of Standards. The instrument is adjusted by a few simple and stable controls, and the angle between the gage block surfaces is read directly from a calibrated scale.

As in other interferometers, the basic principle is that if 2 beams of light from the same source travel along different paths and then come together again, they will form a pattern of interference fringes, the number of fringes depending on the difference in optical path length. Usually, the 2 beams are reflected from different surfaces, so that the fringes give information about the relative position of the 2 surfaces. However, the principle here is more complex.

Looking through the eyepiece, one sees 2 separate interference patterns, one for each of the gage-block surfaces being compared (Fig. 2). Each pattern is formed by the interference of light rays reflected from different parts of the same surface, a result obtained by using a double-image prism. If the 2 block surfaces are parallel, the fringe patterns are also parallel; otherwise the 2 sets of fringes are inclined by an amount that depends on the angle between the surfaces (Fig. 3). However, by placing a glass wedge in the path of the rays and rotating it to the correct position, the fringe patterns may be made parallel. The angle between the 2 surfaces can then be read directly from a suitably calibrated scale attached to the wedge.

The principal optical components are a double-image Kösters prism and a right-angle prism. The double-image prism is made by taking two 30-60-90° prisms, depositing a semi-transparent layer of aluminum on a face of one of them, and cementing the two together with the aluminized face on the inside. The resulting unit is a 60-60-60° prism which is "split" down the middle by the semi-transparent layer. The right-angle prism is used for its well known property that a ray of light entering through the base (face opposite right angle) along any line perpendicular to the 90° edge will emerge, after 2 internal reflections, along a path exactly parallel (and opposite) to its original direction.

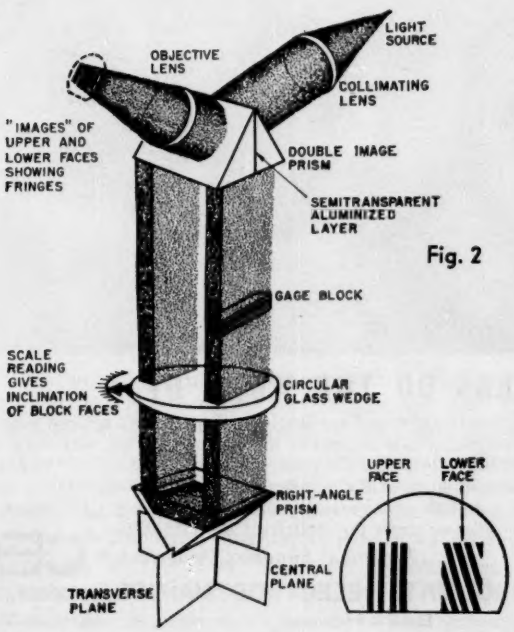


Fig. 2

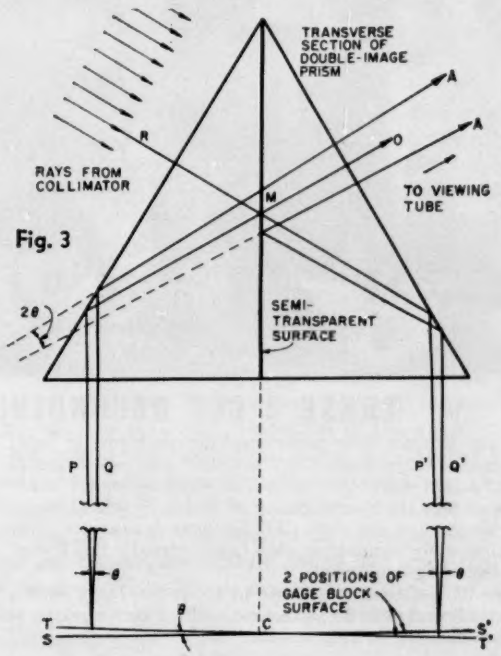


Fig. 3

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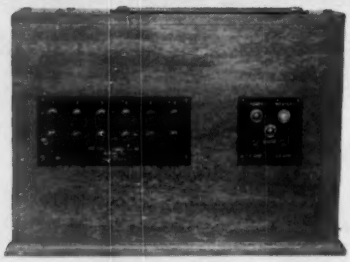
EPPLEY PRECISION VOLTAGE STANDARD AND ASSOCIATED EQUIPMENT



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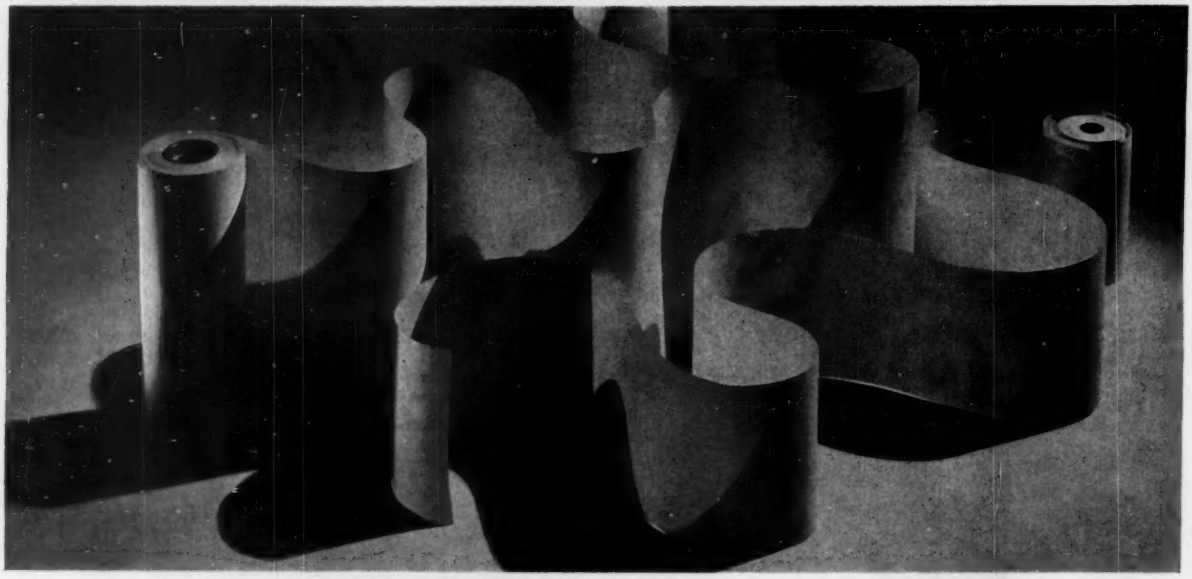

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FIG. 1. GENERAL VIEW of Physical Measurements Laboratory.

The Hamilton Physical Measurements Laboratory

E. C. FECHTER, Hamilton Watch Company, Lancaster, Pa.

THE PHYSICAL MEASUREMENTS Laboratory serves as the Hamilton Watch Co. internal bureau of standards. It administers a set of programs designed to provide adequate gage and measuring instrument controls. It is Hamilton's mechanical and optical measurements center. A primary responsibility of the Laboratory is to assign specifications to all gages and to determine that they meet these specifications.

A temperature of 68°F (20°C) and a humidity of less than 50% are maintained in the laboratory at all times. The laboratory is located on the ground floor to minimize vibration. There is no direct sunlight in the laboratory and it is maintained in a high state of cleanliness.

Grand Master Gage Blocks

The primary measurement standard of the laboratory is the grand master set of gage blocks (121 Blocks, AA accuracy). Through periodic calibrations, the accuracy of this gage block set is traceable directly to the National Bureau of Standards. The grand master set then is used to calibrate the laboratory master set and basic instrumentation. In no instance, therefore, will Hamilton be further removed than a tertiary position relative to the National Bureau of Standards.

Laboratory Equipment

Equipment in the Physical Measurements Laboratory includes the equipment shown in Table 1.

All new, repaired, and puchased *production measuring* equipment, of all types, is inspected in the Physical Measurements Laboratory before being placed in service in the factory. An inspection record card is prepared for each gaging item. Complete data on all measuring equipment is recorded on these cards and the cards are on file in the laboratory.

Production gage equipment is checked at regular intervals by laboratory personnel operating mobile gage-inspection units. Equipment which cannot be checked by the mobile unit is brought into the laboratory. If any gaging equipment is found to be defective, it is withdrawn from service until the necessary corrections are completed. The records kept on all gaging equipment indicate the dates of inspection, readings obtained, and disposition of the gage.

Scribed master projection charts are checked before release for reproduction. All standards and gages checked in the Physical Measurements Laboratory are cleaned, deburred and allowed to normalize so they may reach room temperature before any inspection is performed. Where gages are to be stored, they are first coated in dip seal plastic to prevent corrosion and handling damage.

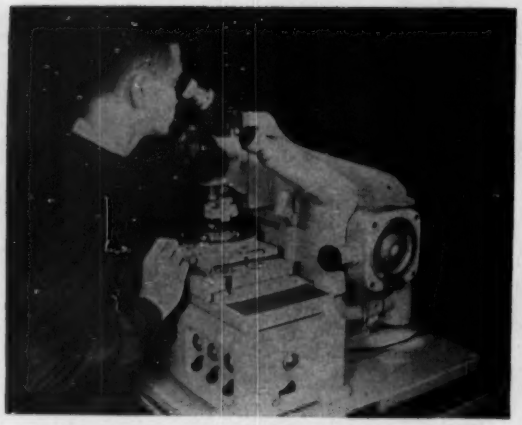


FIG. 2. OPTICAL coordinate measuring.

FIG. 3. HAMILTON-MADE indicator setup plugs (Production).

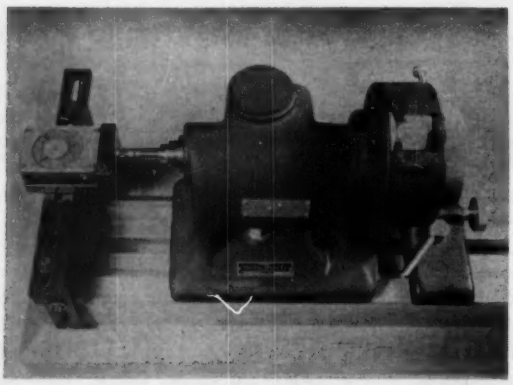


FIG. 4. SETUP for checking Hamilton KwikChek dial indicator.

Table 1—Equipment in Physical Measurements Laboratory

1. Pratt & Whitney Standard Measuring Machine
2. Federal Horizontal Master Internal-External comparator (Model 136)
3. DoAll Electronic Comparator (Model 10)
4. Federal Electronic Comparator (Model 130)
5. Hauser Optical Coordinate Measuring Machine
6. S.I.P. Master Contour Projector
7. Merz Electronic Height Gage
8. Micrometrical Profilometer
9. Johansson Mikrokator (Models ESZ & E6)
10. Petz-Emery Master Indicator Checker
11. Hauser Tool Makers' Microscope
12. Pratt & Whitney Supermicrometer
13. Gaertner Measuring Microscope
14. Mobile Gage Unit—Carrying a P&W Standard Measuring Machine

Table 2—Readings Obtainable

1. Thickness	0.000,001	(1 millionth)
2. Flatness	0.000,002	(2 millionths)
3. Parallelism	0.000,002	(2 millionths)
4. Internal Dia.	0.000,002	(2 millionths)
5. Internal Depth	0.000,010	(10 millionths)*
6. Linear	0.000,010	(10 millionths)
7. Coordinate (Optical)	0.000,050	(50 millionths)
8. Surface Finish	0.000,000,1	(1/10th microinch)
9. Angular (Mechanical)	0° 0' 1"	(1 sec arc)
(Optical)	0° 0' 5"	(5 sec arc)

*Depending on hole size.

Where purchased equipment is rejected, the normal procedure is to return it to the supplier. If deviations can be corrected at Hamilton to expedite approval and thus production, this action is taken. Approved purchased equipment is treated in the same manner as Hamilton's equipment with respect to accountability, identification, preservation and recalibration controls. The recalibration setup of standards and optical instruments is controlled by a wall chart (using pins) in the Physical Measurements Laboratory. This chart lists equipment and shows dates of calibration. The recalibration of mechanical measuring equipment is controlled by a review of the inspection record cards. The gage clerk determines the need for recalibration based on prescribed interval and date of last recalibration.

When measuring equipment becomes inactive through the completion of a contract, or becomes obsolete because of modification, the items are removed from the fabricating areas and placed in proper storage in the Physical Measurements Laboratory. At this time the record cards for this equipment are transferred to the appropriate inactive file.

The Physical Measurements Laboratory of the Mechanical Engineering Section not only insures the reliability and interchangeability of Hamilton's products, but also, its activities are mandatory on outside customer and Government contract work.

DIMENSIONAL CALIBRATION SURVEY

Here are the results of a survey made by the Aerospace Industries Association on the question of calibration and standards in the fields of dimensional, shock, vibration and force measurements. Sixty-eight firms were surveyed, most with over 500 employees.

Dimensional

Measurement requirements for length, angle, threads, gears, balls, surface and hardness seem to be within present capabilities. However, measurement of diameter appears to be causing difficulty.

Measuring *internal diameters* below 0.250" is of most concern and is reflected as a problem area by companies holding close machining tolerances. Also many concerns, while not claiming this a problem area, are reporting available accuracies which must be viewed with reservations. These claimed accuracies are much finer than the National Bureau of Standards can attain and, in many instances, cannot be justified by comparison to the instrumentation used. It is probable that, should these companies actually need the accuracies reported, they may realize the difficulties involved and be forced to reevaluate their procedures.

Measuring internal diameters above 0.250" is next in importance as being a current problem area.

Measuring *external diameters* is of almost equal concern. Those companies engaged in close machining work are faced with required accuracies beyond the capabilities of current instruments and procedures. The answers supplied give a vivid picture of the dilemma faced by companies in the machining field. The requirements stated are realistic and further study of this area could be rewarding.

Shock, Vibration and Force

The trend of answers in this category point out problem areas only when the field becomes specialized.

Torque presents no problem according to the answering units. *Mass* and *weight* are also treated lightly.

The majority (49) of companies are concerned with a force measurement range of 0 to 100,000 lbs, with many subdividing even this figure on the returned questionnaire. Only four reported an interest in 300,000 to 1,000,000 lbs. and none beyond this.

Seventeen concerns reported a 0.1% or better accuracy requirement for various ranges of force measurements; yet few of these reflected a problem in the required accuracy versus present capability columns.

Questions

Is the NBS ±2 microinch accuracy of calibration for 0.100" to 1.000" gage blocks sufficient for your requirements? Yes 60. No 11.

Where a number of blocks must be wrung together in order to set an internal machine for ring gage measurement, would the possible cumulative error be beyond your gaging tolerance? Yes 21. No 44.

Do you use ring gages for which accuracies of plus or minus ten millionths or better are necessary-? Yes 24. No 42.

Would you be in favor of industry-wide measuring procedures being standardized along ring gage measurement lines as one means toward reducing conflicts of measurement? Yes 65. No 4.

Do you feel there is a drastic need for finer ring gage calibration at the NBS level? Yes 26. No 33.

Do you measure cylindrical plugs, cylindrical masters, or outside diameters on product parts with comparator type equipment? Yes 65. No 3.

Do you find variations of pressure and contact radii contributing to loss of accuracy in the measurement of cylindrical masters and outside diameters in the microinch category? Yes 36. No 26.

Do you encounter difficulty in reconciling gage manufacturer's readings or sub-contractor's measurements with your own? Yes 32. No 41.

Is it necessary to have outside suppliers of precision diameters measure the "piece" with similar equipment to yours in order to achieve satisfactory results? Yes 30. No 40.

Is there a need for NBS calibration of master gears for pitch diameter? Yes 28. No 28.

Is there a need for standardized method of measuring steel balls? Yes 40. No 9.

Do you find contour projectors sufficiently accurate for measurement of thread angles? Yes 58. No 11.

Do you feel there is a need for better equipment for the measurement of the drunkenness of threads? Yes 39. No 27.

Is there a need for better equipment for measuring flatness (planeness) of large surfaces? Yes 40. No 24.

Is there a need for better equipment for measuring roughness below 5 microinches? Yes 34. No 25.

Dimensional

NATIONAL BUREAU OF STANDARDS BEST ROUTINE ACCURACY	RANGE	SUB-CATEGORIES OF MEASUREMENT	YES	NO	REPLIES INDICATE EXISTING ACCURACIES SUFFICIENT PROBLEM ACCURACIES
±3μ-in. ±2μ-in. ±3μ-in. ±4μ-in. ±1μ-in. per inch of length	0.01 to 0.09 in. 0.1 to 2 in. 2 to 3 in. 3 to 4 in. 5 to 20 in.	LENGTH— Gage blocks	58	2	.000001 (1) .000002 (1)
±5μ-in. per inch of length	up to 72 in.	End standards over 20"	19	1	±.0001 (1)
±1μ-in. per inch of length	up to 50 in.	Combination length bars	17	0	
"NO MEASUREMENT"		Product parts	55	7	.000050 (2) .000010 (3) .000005 (1) .000002 (1)
10μ-in.	down to 0.040 in.	INTERNAL DIAMETERS BELOW 0.250"— Ring gages	29	23	.000010 (8) .000005 (10) .000020 (2) .000050 (1) .000004 (1) .000002 (1)
"NO MEASUREMENT"		Product parts	41	22	.000010 (11) .000050 (6) .000005 (4)
±1x10⁻⁵ in. ±3x10⁻⁵ in.	¼ to 2 in. ¼ to 6 in.	INTERNAL DIAMETERS ABOVE 0.250"— Ring gages	42	15	.000002 (1) .000020 (1) .000005 (7) .000010 (4) .000050 (1) .000004 (1)
"NO MEASUREMENT"		Product parts	46	16	.000010 (7) .000050 (6) .000005 (2) .0001 (1)
±1x10⁻⁵ in. ±3x10⁻⁵ in.	up to 2 in. up to 6 in.	EXTERNAL DIAMETERS— Master discs or plugs	47	18	.000010 (5) .000005 (9) .000050 (1) .000004 (1) .000002 (2)
"NO MEASUREMENT"		Product parts	46	14	.000010 (5) .000020 (3) .000050 (2) .000025 (1) .000005 (3)
±0.5"		ANGLE— on angle blocks	35	4	±5" (1) 1" (1) 30" (1) 15" (1)
±0.2" if surfaces are accurately parallel to axis and are flat to within 2μ-in.		on polygons	13	0	
		on dividing heads	34	1	1 SEC.
"NO MEASUREMENT"		on product parts	52	7	3" (1) ± 5" (1) ¼ SEC. (1) 10" (1) 3' (1) 1" (1) 30" (1)
"NO MEASUREMENT"		with theodolites	16	1	1 SEC.
±0.0001 in. up to 10 in. ±0.0002 in. 10 in. to 24 in.		THREAD— Pitch diameter	64	5	.000020 (1) .000050 (1) .000005 (1) .000010 (1) .0001 (1)
2° to 8° depending on pitch		Thread angle	58	5	15" (2) 5" (2) 1" (1)
±0.0001 in. per inch		Lead	58	7	.000050 (3) .000030 (1) .000010 (2) .0001 (1)
		Product parts	58	4	.000050 (2) .0002 (2)
"NO MEASUREMENT"		GEARS— Pitch diameter of master gears	35	3	.000025 (2) .000050 (1)
		Other elements of master gears	31	2	.000025 (2)
		Pitch diameter of product parts	58	4	.0001 (2) .0002 (1) .000025 (1)
		Other elements of product parts	43	2	±.000010 (1) .0002 (1)
		STEEL BALLS— Size	34	8	.000002 (1) .000005 (2) .000010 (3) .000003 (1) .0000025 (1)
±5μ-in.	up to 1 in.				
±3μ-in.	up to 1 in.	Roundness (uniformity of diameter)	24	2	.000010 (1) .000002 (1)
±1μ-in.		SURFACE CHARACTERISTICS— Flatness	64	3	.000010 (1) .000001 (1) 1 Helium Light Band (1)
±1μ-in.		Parallelism	59	4	.000005 (1) .000001 (1) .000050 (1) .000003 (1)
±0.1μ-in.		Surface finish	61	5	.5 RMS (2) 2 Microinches (2) 1 Microinch (1)
	All Brinell Numbers	HARDNESS—	63	0	
		OTHER (specify)— Composition Plating	1	0	

Shock, Vibration and Force

"NO MEASUREMENT"		SHOCK— Spectra	19	1	2% (1)
		Max. acceleration, filtered	22	5	2% 5% 1db (2)
		Max. acceleration, unfiltered	18	5	2% 5% 1db (2)
±1% in the range from 10 to 900 cps, increasing to ±2% at about 6000 cps. —accelerations up to 10g		VIBRATION (SINUSOIDAL)— Acceleration	49	7	5% 2% 1% .0005 (2)
		Velocity	38	6	2% 5% 1% (4)
		Displacement	49	2	2% 1% (1)
±0.05% (10 cps to 6000 cps)		Frequency	48	2	1% (2)
"NO MEASUREMENT"		VIBRATION (COMPLEX)— Acceleration	20	7	10% 1% .0005% 1db (2)
		Velocity	14	3	2% 1% 1db (1)
		Displacement	19	2	10% 1% (1)
		Frequency	20	3	10% 1% (1)
±0.004g ±0.0003g total range:	near zero g near +1g or −1g −1g to +1g	STATIC ACCELERATION— 0 to 1g	22	2	1% .1% (1)
±1%	up to 100g	1g to 1000g's	29	1	.1% (1)
±0.1% ±0.2%	111,000 to 500,000 lb. 111,000 to 1,000,000lb.	FORCE— Proving rings	31	2	.1% .02% (1)
±0.4%	111,000 to 3,000,000lb.	Load cells	31	4	.1% 1% .05% (2)
±0.02%	up to 111,000lb.	Dead weights	39	3	.001% .01% 1% (1)
about ±1.5%	20 in.-lb. to 13,000 in.-lb.	TORQUE—	41	1	±¼% Steady ±½% Transient (1)
±0.0002mg ±0.001mg ±0.01mg ±1 part in 10^6 ±3 parts in 10^6 ±2 parts in 10^6 ±4 parts in 10^6 ±5 parts in 10^6 ±1 part in 10^5	0.05 to 50mg (class J) 1mg to 1g (cl.M) 1 to 10g 10 + 100g (cl.M) 0.3 oz to 50lb. 51 to 1000lb. 1001 to 2500lb. 2501 to 10,000lb. above 10,000lb. (cl.M)	MASS AND WEIGHT—	34	0	

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

PUMP MOTOR IN REMOTE PUMPING STATION IS PROTECTED AGAINST DANGEROUS CONDITIONS IN SUCTION PRESSURE, DISCHARGE PRESSURE, AND MOTOR CURRENT

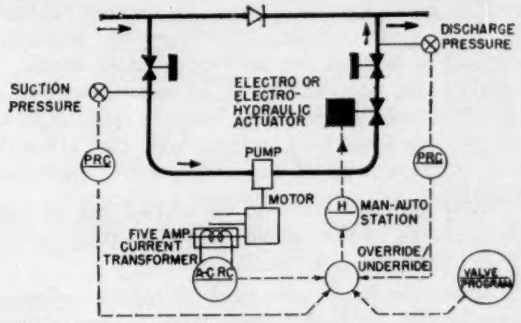
In a remote pumping station, which may be unattended, the pump motor should be protected against too low suction pressure (which can cause cavitation), too high discharge pressure (which can burst pipes), and excessive current (which can burn out the motor).

This system is for a constant-speed induction motor driving a centrifugal pump. Any of the dangerous conditions described will close the valve in the discharge line of the pump. The system is completely electric or electrohydraulic.

The three variables are fed to a unit called an override/underride adapter. The suction and discharge pressures are detected by pressure recorder-controllers (PRC). The motor current is detected by an a-c recording controller A-C RC. The override-underride unit is simply a parallel-diode circuit which permits either the highest or lowest of a given number of input signals to develop an output signal. Thus, if the discharge pressure or motor current becomes excessive, a signal is sent to the valve. Similiarly, if the suction pressure is too low, a signal is sent to the valve.

The valve programmer is a programming unit that permits the station to be replaced on the line after it is shut, by opening the main control valve at a safe rate while the pump motor is restarted.

The PRC's, A-C RC, Programmer, Over-Underride Unit, and Man-Auto Station can all be mounted at the



control station, with electric lines to the remote pumping station.

Equipment used: (2) pressure transmitters, Type P2T; (2) recorders, Type A5R with controllers, Type A8C, with proportional and integral (reset) control modes; manual loading station Model M4C/2; a-c recording controller, Model A5R-A8C with 5-amp current transformer of any reputable make; program controller, Model P3A/5; underride/override adapter, Type A5A; motor current adapter, Type A3A; converter, Model D2C/2 a-c/d-c; and control valve (type depending on piped fluid) with thermo-drive actuator.

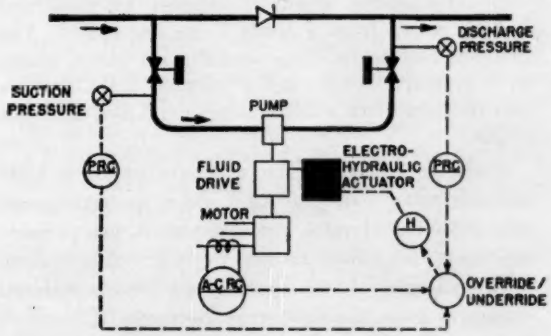
Source: Swartwout Div., Crane Co., Manchester, N. H.

PROTECTED REMOTE PUMP HAS ITS SPEED CONTROLLED DIRECTLY

An alternate technique for remote control of a pumping station varies the speed of the feed pump rather than controlling through a valve (as shown in preceding circuit.)

Here control is accomplished by electrohydraulic actuation of a scoop tube in a fluid-drive power-transmission device. The override/underride unit receives three signals (suction-pressure controller, discharge-pressure controller, and current controller). The dominant signal goes through a manual/automatic station into the electrohydraulic actuator.

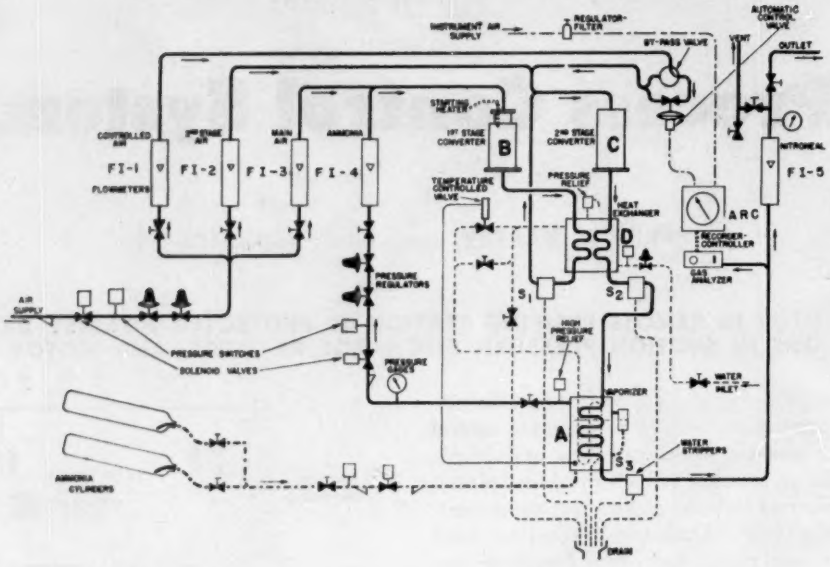
Equipment used: (2) pressure transmitters, Type P2T; (2) recorders, Type A5R with controllers, Type A8C, having proportional and integral (reset) control mode; manual loading station, Model M4C/2; underride/override adapter, Type A5A; current controller, Type A8C with A5R recorder; motor current adapter, Type A3A; a-c/d-c converter, Model D2C/2.



Electrohydraulic actuator and fluid drive (any reputable make).

Source: Swartwout Div., Crane Co., Manchester, N. H.

CONTROL SYSTEM FOR INERT GAS GENERATION



Many processes have to be carried out in inert atmospheres, as they would otherwise extract oxygen from the air and cause oxidation.

Among the inert gases (such as common nitrogen, hexafluorite, etc.), Nitroneal takes a special place, as it is an oxygen-free (less than 1 ppm) nitrogen gas with a controllable hydrogen content of from 0.5% to 25%. In its production air and ammonia react with each other over a platinum catalyst in two converter stages. The basic control of the composition of the product is via a gas analyzer that controls the amount of mixing air.

The control system illustrated shows the supply air entering on the left through a strainer, a solenoid valve, and two pressure regulators (for closer regulation). The pressure switch between the valve and regulator shuts down the generator at low pressure (as do the pressure switches in the ammonia vapor and water lines).

The air is divided into 3 streams: Controlled air, second stage air, and main air. The three streams are metered by rotameters, FI-1, FI-2, and FI-3.

Liquid-ammonia supply (indicated by dots and dashes) comes from a bottle (with one spare). The ammonia line has hand-operated shut-off valves, strainer, a pressure switch, and a solenoid valve. It then goes to a vaporizer which changes the liquid ammonia to gas.

After the vaporizer, the ammonia passes a high-pressure relief valve, a hand valve, pressure gage, strainer, solenoid valve, pressure switch, two pressure regulators, and a hand throttle valve. It then is metered by a rotameter (FI-4) and mixes with the main-air stream to enter the first stage converter (B), which has a starting heater (used for start-up). The mixture then passes through a heat exchanger (D), is cooled and stripped of water content in stripper S_1, and from there goes to the second-stage converter C. Here the gas stream meets the second-stage air stream (when needed to produce low hydrogen content gas) and the controlled air stream.

The controlled air from FI-1 passes through a control valve which is stroked by analyzer recorder-controller ARC. This controller analyzes the % hydrogen in the final product (Nitroneal) and controls the flow of mixing air. A by-pass arrangement allows manual operation. Hand throttle valves in the three air lines are provided for use as required.

After leaving converter C, the gas gives off its heat in the heat exchanger D, is stripped of entrained water vapor in stripper S_2, and passes through vaporizer A, where its remaining heat is utilized to vaporize the liquid ammonia.

After being stripped of the last traces of water vapor in a final stripper S_3, the Nitroneal gas is metered by a rotameter (FI-5) and piped to the consumer. The finished gas is delivered at a pressure of 2 psig with a dew point of +40°F.

Of the auxiliary utilities, (1) instrument air passes through a filter-regulator to supply the controller. (2) water used as a cooling medium is piped to the heat exchanger D through a pressure regulator (with a pressure switch guarding the line). From the heat exchanger the water flows through a control valve to the vaporizer. When the ammonia in the vaporizer gets too cold, a vapor-tension bulb located in the vaporizer sends a signal through a capillary to the temperature regulator ("temperature controlled valve") in the water stream to the vaporizer. Hand-operated shut-off valves permit various bypasses to the drain.

Pressure relief valves guard the ammonia line emerging from the vaporizer, and the heat exchanger.

The thermo-conductivity type gas analyzer signals an electronic-pneumatic controller with proportional and reset modes. Controller-recorder, control valves, rotameters, regulators, relief valves, pressure gages, and pressure switches can be of any make.

Source: Engelhard Industries, Inc., Industrial Equipment Division, Newark, N. J.

Continued on page 1653

Heat Cycle Analysis

R. D. RAGLE
S. G. DUKELOW
Bailey Meter Co.

EACH COMPONENT unit in a power plant deteriorates to a degree with time, and the total accumulation of these small deviations can have appreciable affect on over-all heat rate.

The continuous computation of heat rate can be implemented by either analog or digital computing techniques. Computation of net unit heat rate can be accomplished by either of two methods:

1. *Input-Output,* where fuel flow into the boiler and net generation are measured.

2. *Heat Loss Method,* where boiler efficiency is measured by the ASME heat loss method and fuel input is determined by dividing boiler efficiency into the Btu/Hr heat flow into the turbine cycle. The result of either method of computation is net unit heat rate in either Btu per kilowatt-hour or dollars per kilowatt-hour. The continuous record of either is extremely useful to operator and results engineer alike.

The heat-type computer should provide a resolution of about ¼ of 1%. The expected long-term repeatability is about ½ of 1%. Thus, this computation does not provide a means of detecting small changes in component efficiencies. For example, the complete outage of a feedwater heater located in the middle of the low pressure string will cause an increase in rate on the order of ¼ of 1%. This is on the borderline of the resolution limit of the over-all heat-rate computation. Yet, a measurement of the condensate enthalpy rise across the heater provides a ready indication of whether the heater is operating properly or not. This suggest the possibility of being able to make relatively simple measurements and mathematically relating the results to over-all heat rate.

Bailey Meter Company, in conjunction with J. Kenneth Salisbury, has developed a mathematical method for accomplishing this. With this method, any component deterioration, as measured by commercial instrumentation, can be expressed in terms of its effect on over-all heat rate, with an expected accuracy far greater than can be achieved with an over-all heat-rate measurement. The basis of this concept is that each component can be considered to be contributing a "gain" in heat rate, the base component being a low-pressure turbine operating non-extraction.

The initial Input-Output Heat Rate Computer went into operation early in 1957 (Delta Station of Mississippi Power & Light Company). This computer was built in standard analog recorder units using well-known analog computing circuits. Several such installations were made in 1959 and 1960*.

In order to improve the accuracy of computation, equipment was designed specifically for this purpose. Installations using the present "function generator" equipment have been furnished to nine different utilities in 1959 and 1960**.

Six of these computers are applied to Gas and Oil Fired Units. In these cases the Input-Output computation is used. Output is Net MW and Input is Total Btu based on Fuel Measurement with appropriate compensations for Btu, specific gravity, pressure and temperature. In the Pacific Gas and Electric Co., fuel cost for gas and oil fuels are factors so that the readout is also given in terms of $ cost per KW-hr. Deviation from heat-rate standard is also provided in most of the installations, with the standard adjusted in accordance with cooling-water temperature or other factors.

The Cleveland Illuminating Company installation and the Rochester Gas and Electric Company installation are coal fired and thus input cannot be readily measured. For the computation of *heat input* it is necessary to first compute *boiler efficiency* and use this factor along with measured *boiler heat output.* Otherwise Input-Output calculations are made, along with deviation from standard heat rate.

The Indiana Michigan Electric Company, Breed Station installation uses the "gain" approach to performance computation wherein the gain or deterioration in performance of various areas of the unit are monitored.

Most experience to date has been concerned with the computer's use as an operating guide. With this equipment every operator can act as a Test Engineer to maintain optimum plant performance at all times.

The installation at New York State Electric & Gas Co., Milliken Station, is a digital installation in which data is taken hourly and stored on punched tape. Each month the tape, containing 720 sets of data, is used to punch cards, and the load-weighted average heat rate is computed on a digital computer located at the main office.

Abstracts from paper presented at ISA Power Conference, San Francisco.

*Mississippi Power & Light Co., Rex Brown Station; Oklahoma Gas & Electric Co., Horseshoe Lake Station; Brazos Electric Power Coop., Weatherford, Texas.

**Pacific Gas & Electric Co., Moss Landing & Hunter's Pointer Stations; Oklahoma Gas & Electric Co., Mustang Station; Southwestern Public Service Co., Nichols Station; Public Service Co. of New Mexico, Reeves Station; City of Los Angeles; Scattergood Station City of Lafayette, La.; Cleveland Electric Illuminating Co., Ashtabula Station; Rochester Gas & Electric Co., Beebe Station; New York State Electric & Gas Co., Milliken Station.

REMEMBER COLLAR BUTTONS?

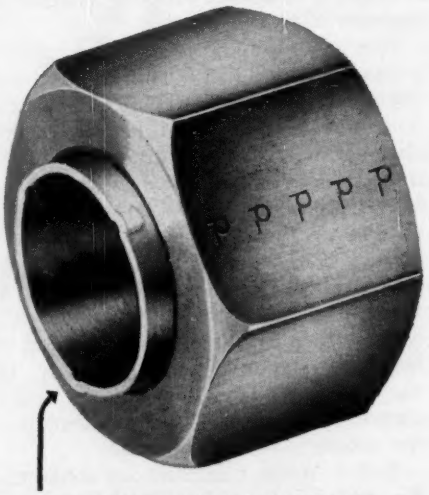
NOW **PARKER** HAS ELIMINATED A MORE SERIOUS ANNOYANCE ...LOST TUBE FITTING FERRULES!

A simple change in the design of Parker "Intru-lok®," the positive, bite-type Parker fitting for copper, aluminum or plastic tubing, has solved an age-old problem.

Small three- and four-piece tube fittings have long been a pain in the neck on applications where it is necessary to remove the nut from the fitting. The ferrule(s) fall out and promptly disappear. If and when found, they often get put in backwards. Sometimes they never get put back at all. Result, in either case: a leaking joint.

Now Parker has developed a snap-in, captive ferrule for "Intru-lok." You can take it out of the nut, "on purpose," but you can't drop it out accidentally.

You get all the leakproof safety of a three-piece fitting with positive "bite." You also get the convenience, the quick, easy assembly of a two-piece fitting. The easiest fitting to install has been made even easier. Write for new "Intru-lok" dimensions and prices today.



Three "detents" hold the "tail" of the new ferrule in the nut. Also, the larger hole in the nut makes tube bends closer to the fitting possible. Note the larger wrench flats on this huskier nut, too.

The new nut with captive ferrule is available on all "Intru-lok" fittings sizes from #2 through #8 (1/16" through 1/2" O.D.). Shown below actual size:

PARKER HANNIFIN CORPORATION

PARKER-HANNIFIN

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue • Cleveland 12, Ohio
PNEUMATIC AND HYDRAULIC SYSTEM COMPONENTS

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CIRCLE 101 ON READER-SERVICE CARD

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Sliding-Disc-Valve Regulator

O. F. NELSON
Northern Illinois Gas Company

The sliding-disc valve has the advantages of a gate valve (straight-through flow and economy) without its disadvantages (poor shut-off and easy fouling).

V PORT and "Throttle Plug" are common names used in the gas industry to describe a regulator, but "sliding disc" is a new term in the regulator field. The sliding-disc valve, as a shut-off valve, is not new to the gas industry; it has had wide acceptance as a shut-off valve for fuel gas to boilers and on boiler blow-down service. (The Maxon valve on your boiler fuel line is a sliding-disc valve.)

A few Northern Illinois Gas Company engineers and an outside sales representative wondered if this type of valve would operate as a regulator. A 4" valve was fitted with an air cylinder and a positioner for trial use. The results of this test were so surprising that a sliding-disc regulator was designed and tested at many locations.

Features of a Sliding-Disc-Valve Regulator

Fig. 1 is a cross-section of a double-seated sliding-disk valve showing stem, disc carrier, disc and seats. The seats are screwed into the two halves of the body and their surfaces are held parallel. The discs float in the disc carrier and thus align themselves to their seats. The carrier is attached to the stem and swings the discs in or out of the flow line of the valve. The discs are free of wedge action. (A typical gate valve would have tapered gate for tight closing against seats

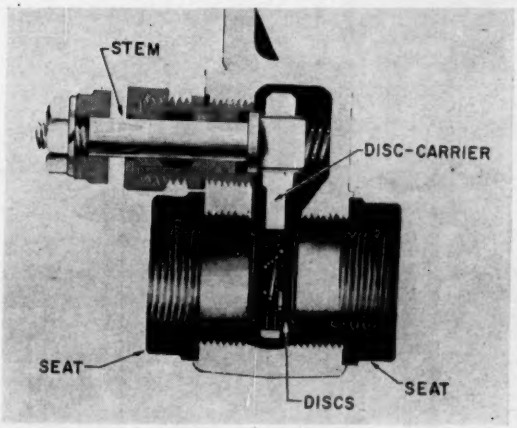


FIG. 1. DOUBLE-SEATED sliding-disc valve.

Meeting: Thur., Oct. 19, 1961—Rio Hondo Country Club, 10627 South Old River Rd., Downey, Calif.
Program: "Development of a Multi-Element Boiler Combustion Control System," by J. W. Roth, Bailey Meter Co.
Demonstration: Honeywell's new line of miniature pneumatic instrumentation will be shown by Glenn Fosburg, Minneapolis-Honeywell Regulator Co.

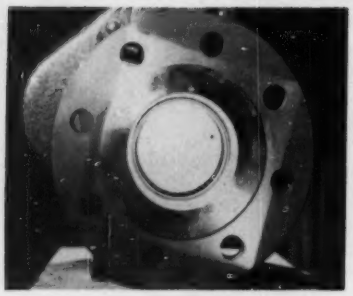


FIG. 2. DISC slides into pocket at left to open valve.

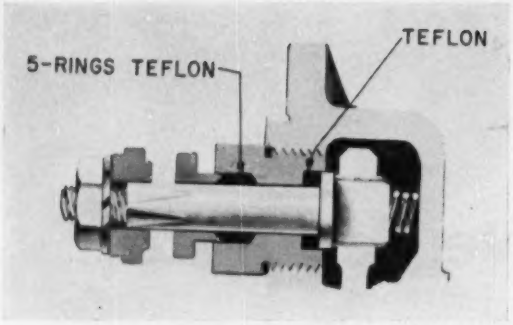


FIG. 3. STEM rotates in Teflon seals.

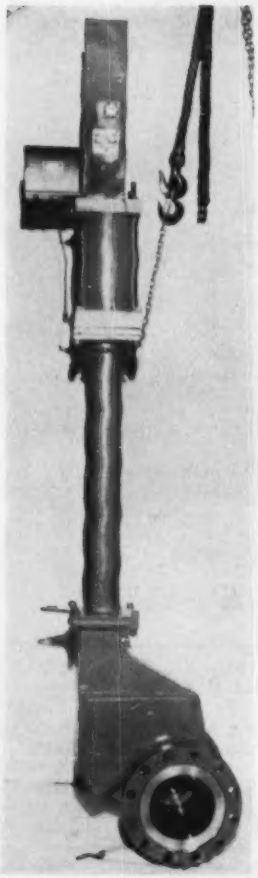


FIG. 4. VALVE plus actuator is regulator.

incorporated in the valve body. The valve used in the sliding-disc regulator has seats in the valve body and the discs are free floating, thus aligning themselves to the seats. The surfaces of the disc and seats are micro finished and differential pressure is all that is needed for closure of the valve.)

Line pressure holds the downstream disc firmly against its seat for tight shut off. In the double-seated valve shown the discs are held slightly apart by a spring which provides about 5 pounds pressure. The forward disc backs away from its seat to allow upstream pressure to firmly seat the downstream disc.

The mating surfaces of seats and discs are lapped to 3 to 5 millionths of an inch. The seats and discs are available in many material combinations. We have used type-440 stainless-steel seats with a Brinnell hardness of 510, and stellited discs with a Brinnell of 610. No cutting of surfaces has been found during inspections. The surfaces have, in fact, been burnished to a brighter-than-new condition.

The description "sliding disc" is not entirely accurate because actual testing has proved that the discs tend to rotate a slight amount with each opening and closing operation. This movement of the disc across the seat is a wiping action and cleans the surfaces. Thus, positive shutoff is obtainable with metal seats.

Fig. 2 is the end view of the valve. The bulge on the left side is the pocket into which the discs are moved to place the valve in the wide-open position. The open-to-close motion of the discs requires a maximum of 67 degrees of stem rotation. Full flow through the valve is obtainable in the open position.

Fig. 3 is a cross-section of the stem and packing. The stem is highly polished to provide a fine finish for a packing seal. The inside ring is Teflon. The outside packing consists of five Teflon rings. Each of these five rings are "V" shaped, or Navy wedge design, to insure sealing with a minimum of gland pressure.

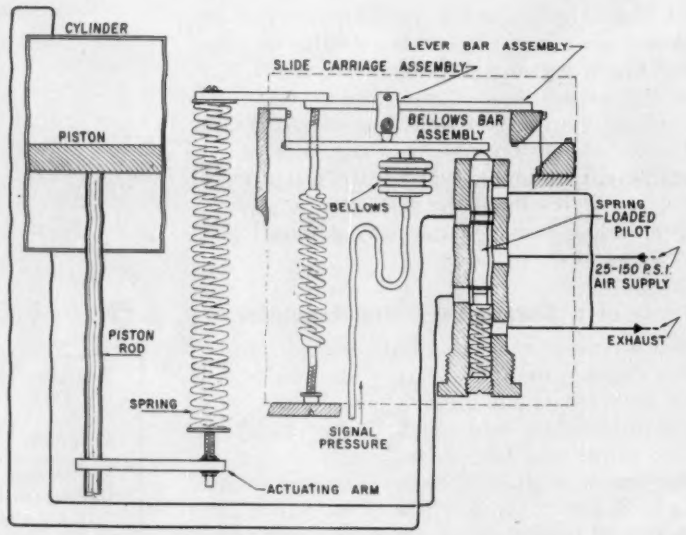


FIG. 5. CYLINDER actuator and positioner.

Many may claim that a "sliding disc" is just another name for a gate valve. However, gate valves plug with dirt and do not close. We have found no dirt in the slot of the sliding-disc during inspections; after three years of field testing, we have had no trouble in getting the sliding-disc valve to close.

Fig. 4 shows the valve with a cylinder and positioner, all that is necessary to produce a regulator.

Fig. 5 is a diagram of the positioner and cylinder actuator. The 3-15-psi signal from the controller is fed into the bellows. As the pressure increases, the bellows lifts the bar assembly and allows the spring-loaded pilot valve stem to rise. High-pressure air is passed through the pilot valve to the top of the air cylinder. Exhaust air from the lower cylinder chamber is exhausted through another port in the pilot valve. The piston movement is transmitted through an actuating arm and spring. Downward movement lowers the lever bar assembly; the assembly pivots about the two flexure strips at top right. Movement of the slide carriage assembly opposes the movement of the bar assembly and closes off the exhaust parts of the pilot valve. Each signal pressure increase will result in a definite position of the piston. A toggle is provided to reverse the action of the positioner.

A 4" unit was installed at a remote flow-controlled station four years ago. Inlet pressure was 250 psi and outlet pressure 150 psi. Flows were in the range of 0.2 to 1.5 million cfh. The valve went into service with no trouble, and followed the set point of a remote-set flow controller. No hunting was evident on this service; the line on the flowmeter chart was almost a perfect circle. This unit was moved to another station where the inlet and outlet pressures were about the same, but flow was about 5 million cfh. It is still in service and has shown no signs of erosion. The valve operates through a complete control range. No hunting is evident from zero flow to about 3.5 million cfh. The control from full-open position (4.25 million cfh) down to 3.5 million cfh is similar to most regulators (normal range of operation for good control with any regulator is usually below 80% capacity).

This unit could not be buried and flexible hosing was necessary to supply gas to the cylinder. Revamping of this valve to allow below-ground installation and to eliminate the air hose connections was the first modification.

Fig. 6 shows the first modification, which incorporated a housing for the torque arm, a flange-mounted cylinder and a new mounting for the positioner. This regulator is a 2" double-seated unit. Inlet pressure varies from 250 to 650 psi and the outlet pressure is maintained at 150 psi. The unit was installed above ground solely for inspection purposes. It is on straight pressure control and has been doing a good job for two years.

This unit had a high noise level while on control. It was found on inspection that the upstream disc was vibrating. This disc was removed, making the regulator into a single-seated unit, and the noise level was reduced substantially.

The current unit incorporates the features necessary to modify a sliding-disc valve for above- or below-ground installation. It is a simple, easily-maintained unit. The housing is now an integral part of the valve body. The extension consists of a flanged spool piece and an extension shaft which allows easy conversion from above- to below-ground installations. The positioner is mounted on a separate plate which also holds the reversing toggle. The position indicator is visible through a double window. The positioner spring also is protected in the upper housing. Hoses have been replaced with tubing.

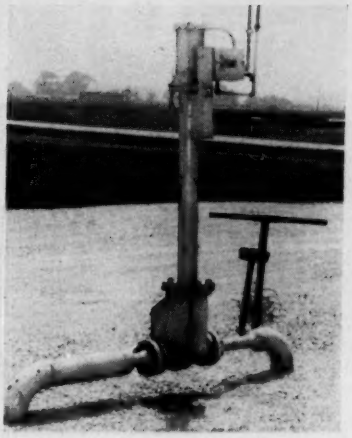


FIG. 6. SECOND prototype in line service.

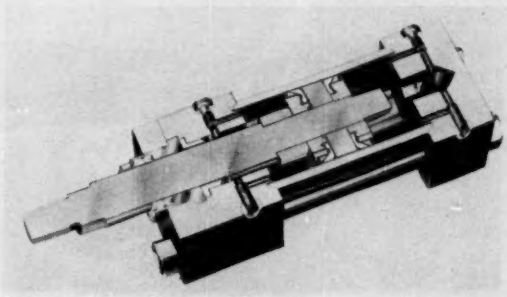


FIG. 7. SECTION of air cylinder.

Many regulators of the sliding-disc design are in service under both flow and pressure control.

Air Cylinders

A valve regulator using pneumatic power and in modulating service requires a cylinder that has the following characteristics:

1. **Low breakaway pressure for smooth control, regardless of temperature. (Breakaway pressure is the differential pressure necessary to start the piston moving.)**
2. **No gas leakage past the piston cups over a wide range of temperature.**
3. **No lubrication requirement—the small movements of the piston level are not enough to create a differential across a lubricator to carry oil to the cylinder.**

Only one cylinder was found to meet all these specifications from −20°F to 125°F.

Fig. 7 is a cross section of the cylinder we are now using. This unit has spring-loaded, expanded Teflon cups. The seals also are Teflon and the tube is sealed to the end flanges with a Teflon ring. The tube bore is chrome plated to eliminate rusting and to provide a perfect surface for the Teflon cups. The rods are case hardened and chrome plated.

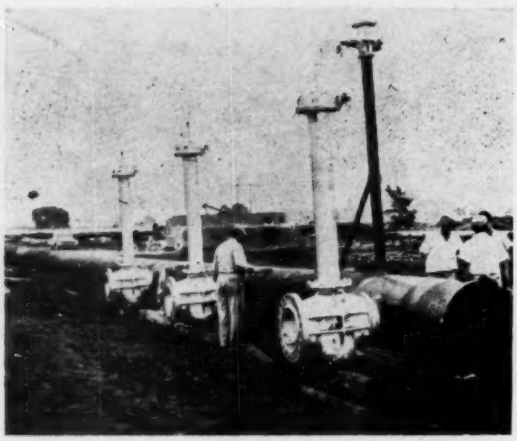


FIG. 8. **UPSTREAM** header for regulator station.

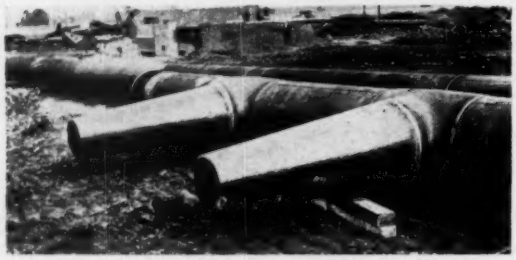


FIG. 9. **TAPERED** sections leading into downstream header reduce noise.

FIG. 10. **DISTRIBUTION REGULATOR** of the future.

Why develop a new regulator when so many types of regulators are available? The sliding-disc valve, we felt, could help eliminate some of the problems in present-day conventional equipment—wider rangeability, increased flow with a single unit, positive shutoff with metal seats, all at both summer and winter operating conditions.

Experience with these units and other buried valves has altered our thinking on piping a regulator station. Fig. 8 shows a conventional header on the high side of a regulator.

Fig. 9 illustrates the revisions incorporated on the downstream side of the regulator in an effort to reduce noise. The long tapered pieces are graduated from the size of the valve regulator to the full size of the header. The shut off valve is supplied at a convenient place in lieu of a standard valve being installed directly on the outlet manifold. The 8″ regulators discharge into a 30″ manifold. Inlet pressure is expected to vary between 375 and 750 psi. The downstream pressure will be 150 psi. The regulator run is to handle 10 million cfh.

This is one of the applications where we feel sliding-disc valves will help. We have used the sliding-disc valve to replace conventional equipment in existing regulator runs to increase flow without changing pipe. We also have changed an existing regulator run, where pressure loading of a station made it necessary for us to add a monitor regulator, by replacing the downstream shutoff valve with a sliding-disc valve as a combination monitor and shutoff valve.

To date, we have not installed a unit of this type for distribution use. Three sliding-disc valves might be bolted together as a common replacement for a conventional regulator vault. The existing regulator would require modifications of controller and positioner for this service. These ideas are being studied, and in the near future a unit will be available that would be acceptable for distribution use.

Fig. 10 shows what a home owner might see in his parkway as the distribution regulator of the future.

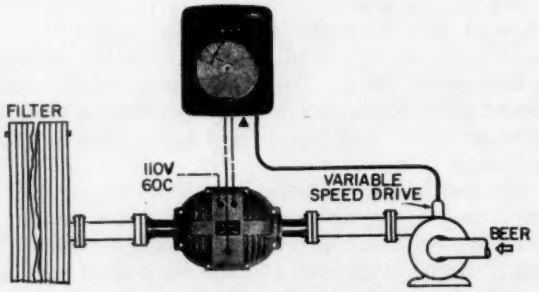
FLOW THROUGH BEER FILTER KEPT CONSTANT

In a brewery, flow through a filter diminishes as the filter mass builds up with time and use. Experience has shown that plate-and-frame filters operate most efficiently when the flow is constant.

Constant flow is assured by this system, in which a magnetic flowmeter measures the flowrate and sends a proportional electric signal to a recording controller. This controller produces a pneumatic control output which, when piped to the cylinder actuator on a variable-speed drive, regulates the centrifugal pump to keep the flow constant through the filter, at the rate set on the controller.

Time for cleaning or replacing filters, and money lost in shut-down, is saved.

Equipment: Magnetic flowmeter; Dynalog flow recorder-controller with proportional plus reset control mode.



Source: Foxboro Company, Foxboro, Mass.; also Application Engineering Data 208-7.

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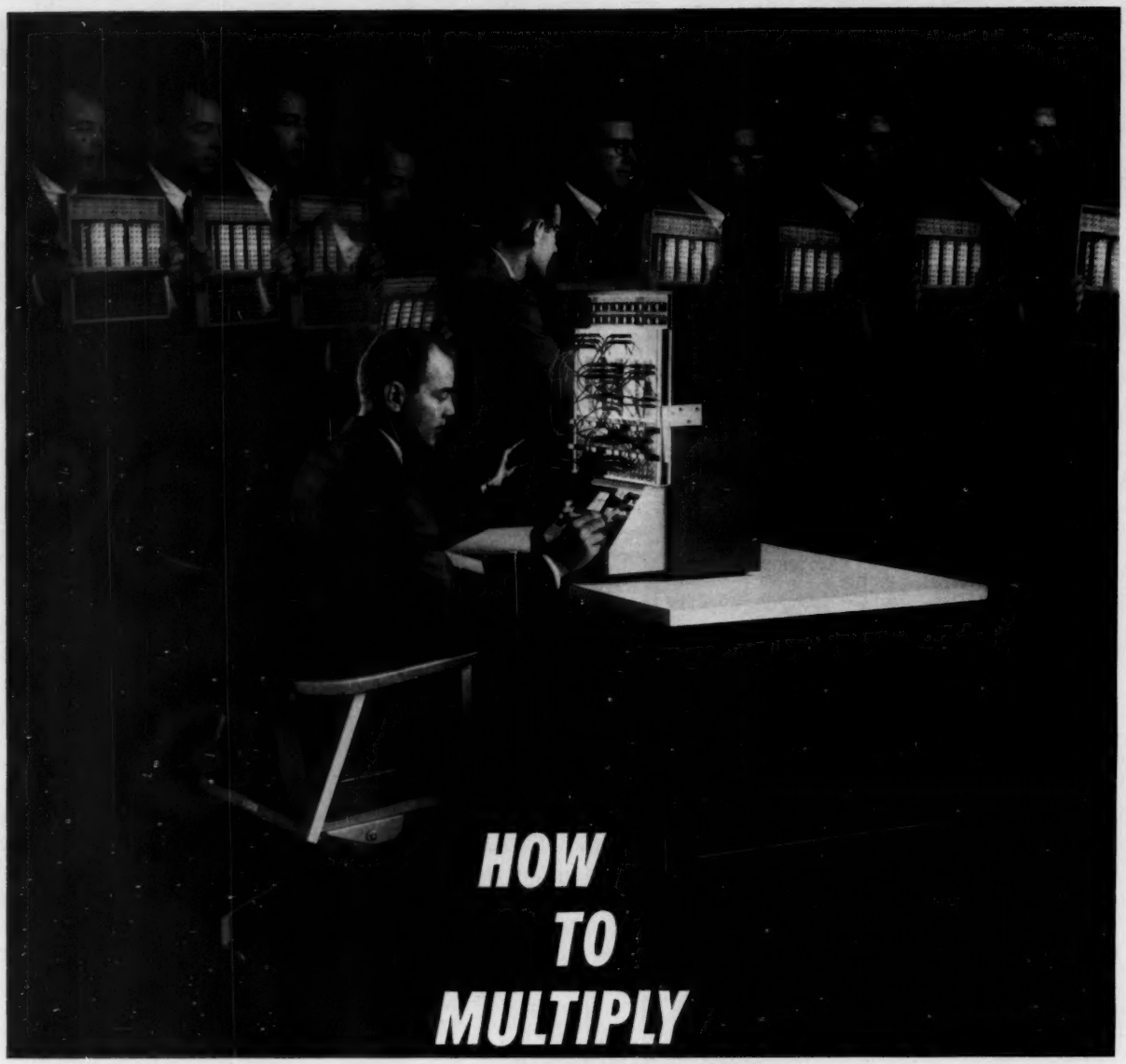
CIRCLE 102 ON READER-SERVICE CARD



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CIRCLE 103 ON READER-SERVICE CARD

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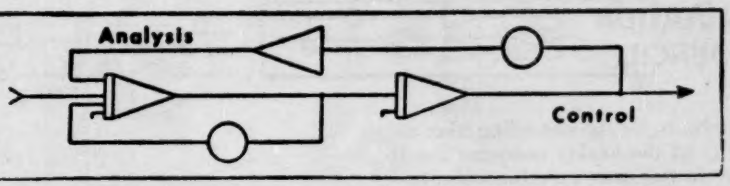

Newsletter

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Bits

Under PIECES:

Central Simulation Council:
Humble-Baytown, 13 March 1961; "Analog + Experimental Measurements = Practical Engineers' Answer" by *T. R. Herndon and Ralph James*

"Determination of Telephone Trunk Loading"; "Strain Gauge Data Reduction"; "Multiplier Accuracy Improver" by *T. R. Herndon*

Central Simulation Council:
Kansas State University-Manhattan, 9 May 1961

Brief description of Papers:

"Simulation of the Fractional Derivative Operator $\sqrt{s}$ and the Fractional Integral Operator $\sqrt{1/s}$" by *Gordon E. Carlson* and *Charles A. Halijak*

"Analog Computer Study of an Adaptive Control for Closed-loop Systems" by *C. H. Thomas*

"Electronic Analog Computer Representations of Induction Motors with Unbalanced Terminal Voltages" by *P. C. Krause, Jr.*

"Digital Approximation of Differential Equations by Trapezoidal Convolution" by *C. A. Halijak*

"A Theory of the Single-Input-Output Experiment" by *P. G. Kirmser*

Southeastern Simulation Council:
Univ. of Alabama, 14 April 1961

Digest of "Sampled Data Control Systems" by *P. M. Julich*

"Some Application of Diode Bridges" by *James Spear* (complete paper).

Under ANALOG TECHNIQUES
"Setting Integrator Capacitors" by *Tom Anderson*

Under SCI ACTIVITIES
The 400th member
The Midwestern SC meeting of May 15th
The Rocky Mountain SC meeting of June 27th

Under INFO
Call for Spring JCC papers

Under LETTERS
Milt Aronson
Mark Connelly

Pieces

CENTRAL STATES S/C MEETING OF 13 MARCH ON ANALOG MEASUREMENTS, TELEPHONE TRUNK LOADING, DATA REDUCTION, MULTIPLIER ACCURACY

Of the Central Simulation Council meeting held on 13 March 1961 at Humble Oil & Refining Company, Baytown, Texas, *T. R. Herndon* writes:

"After a welcoming by the Assistant Plants Manager, Mr. *J. R. Barsalou*, the meeting got under way.

"The first paper was given by Mr. *J. E. French* of Ling-Temco, Dallas, entitled 'Analog Computing at Temco.'

"Ed gave us a bit of the history of computing at Temco, starting with a BEAC, up to the present with three Electronic Associates 231R consoles and one 16-31R console. He listed the equipment and told us something about the problems worked. Most impressive to me was the amount of work done on the old BEAC. Ed gave us the background of those involved in analog work at Temco. He mentioned that the computers at Temco are now available on a rental basis.

"After a short coffee break, Dr. *Max Gilliland* of Beckman/Berkeley described some interesting recent advances in the repetitive phase of the business made by his people. From looking at notices of WJCC, I have come to the conclusion that this or a very similar thing will be given there.*

"The next paper, 'Analog + Experimental Measurements = Practical Engineers' Answer,' was given by *Ralph James* (Staff Engineer, Humble Oil)."

Ralph's paper began with a hypothesis:

"The classical theoretical equations for physical phenomena can be applied to many engineering problems. Often, however, simplification is necessary and assumptions must be made in order to expedite the solu-

*This is not true", writes Max, "Inasmuch as the paper I gave there is the same one I gave at Tucson—" The introduction and conclusion were given in the August *Newsletter*. Copies of the complete paper are available from Max, c/o Research Department, Berkeley Division/Beckman Instruments, 2200 Wright Avenue, Richmond, California.—Ed.

tion or to avoid exceeding the capacity of the analog computer available. In this case, experimental measurements often may be applied to eliminate or make more accurate the necessary assumptions. In addition, measurements may help determine whether or not the simplified mathematical model provides the accuracy desired.

"These concepts are certainly not new to those familiar with analog computers. It has been observed, however, that engineers do not generally recognize that a useable mathematical model need not be exact or complete. Also, experimental measurements are avoided by many engineers because of the belief that laboratory precision is required. To the contrary, simple mathematical expressions checked out by relatively crude measurements are adequate for many practical problems." To illustrate, and to provide thought starters for similar problems, an illustrative problem was presented.

The paper went on to describe work done at Humble in the cooling of butyl rubber—the process, the simulation of it, details concerning measurements to verify and calibrate the model, and results. "The simulation-modification of the rubber cooling facilities, with temperatures as predicted, has been most gratifying," Tom's letter continues. "As you will notice, I was listed as co-author. All I did was to get behind a very busy engineer and push, fuss, cuss, and discuss until this paper was an actuality."

"The next paper, 'System Optimization' by Mr. *Walter Brunner* of the Princeton Computing Center of Electronic Associates, was given at the WJCC," so it will not be covered here.

"After lunch I gave my paper entitled 'Some Applications of Analog Computing Elements to Data Reduction and the Development of An Accuracy-Improving Device for Multipliers.' This mouthful describes some fairly simple-minded things done here at Humble."

However, your Editor found these "simple-minded" examples unusual enough to be of interest, so we present here excerpts of this paper:

Herndon on Telephone Trunk Loading

The Baytown Refinery of Humble Oil owns and operates its own automatic telephone system consisting of some 1,600 lines. Three years ago the Humble operators had to handle many calls several times, and they complained to their supervisor, requesting more help. "However, an additional operator to say 'I'm sorry, the lines are busy,' was obviously not the answer," Tom said.

"Trunk loading can be determined by sampling and the application of Queing theory. It also can be determined by direct measurement using analog computer hardware. The latter method was chosen because of the number of samples required, etc.

"Subsidiary information needed was the proper number of operators to supply to the second and third shifts.

"The analog solution to this problem was simple, though the problem was not. An operational amplifier was connected as a summing amplifier with the input resistors connected to a battery through trunk-relay spare contacts. The amplifier output was displayed as a series of equal-height steps plotted against time using a strip-chart recorder.

"As a result of this study, additional trunks were supplied and dialing added to the Houston Office. It has been possible to reduce the number of operators and their work load.

"The amplifier and recorder have been used many times since then to study loading. Indicated changes have been made to the improvement of the telephone system."

Herndon on Strain-Gauge Data Reduction

"The manual reduction of strain-gauge data is very tedious when stress is varying with time, as in the case in piping pulsation and vibration caused by reciprocating compressor operation. To determine stress using strain gauges, three strains are measured, two at right angles and one at 45° to the other two. The outputs of the gauges (elongations) are recorded simultaneously and then the fun begins! The stress analyst attempts to compute maximum and minimum stress using the formula:

$$S = \frac{E}{2}\left\{\frac{e_1 + e_3}{1-\mu} + \frac{1}{1+\mu}\sqrt{(e_1 - e_3)^2 + [2e_2 - (e_1 + e_3)]^2}\right\}$$

where E is Young's modulus, μ is Poisson's ratio, $e_{1,2,3}$ are elongations due to load (strain), S is stress.

"This formula has been programmed using a portable group of 10 amplifiers (circuit shown in Fig. 1). The equipment has not yet been connected to the strain-gauge amplifiers, but no difficult problems are foreseen.

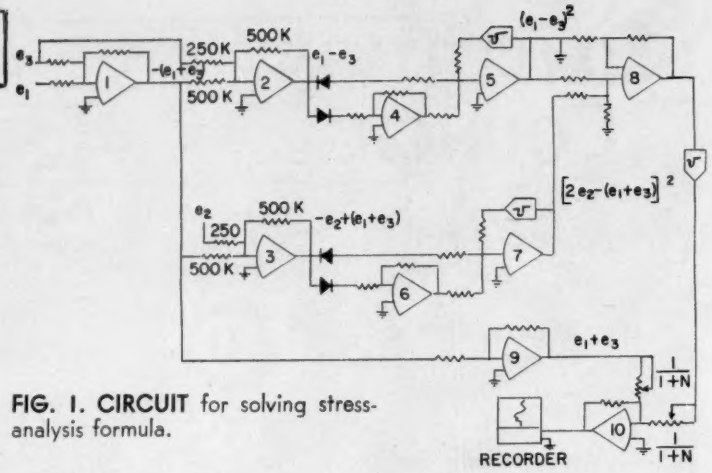


FIG. 1. CIRCUIT for solving stress-analysis formula.

Herndon on Multiplier Accuracy Improver

"Electronic multipliers have a common failing. When voltages near zero are multiplied, the percent error may be quite high. With some types of multipliers, the output may even have the wrong sign. This is disastrous to many simulations.

"In an effort to reduce multiplier error, the circuit shown in Fig. 2 was devised. This device makes automatic scale changes to both input and output (to preserve scale) when either or both inputs are below ten volts, that is, when the voltage to input "X_1" goes below ten volts. As sensed by a built-in comparator, a fast relay operates interposing an amplifier with a gain of ten and an inverter be-

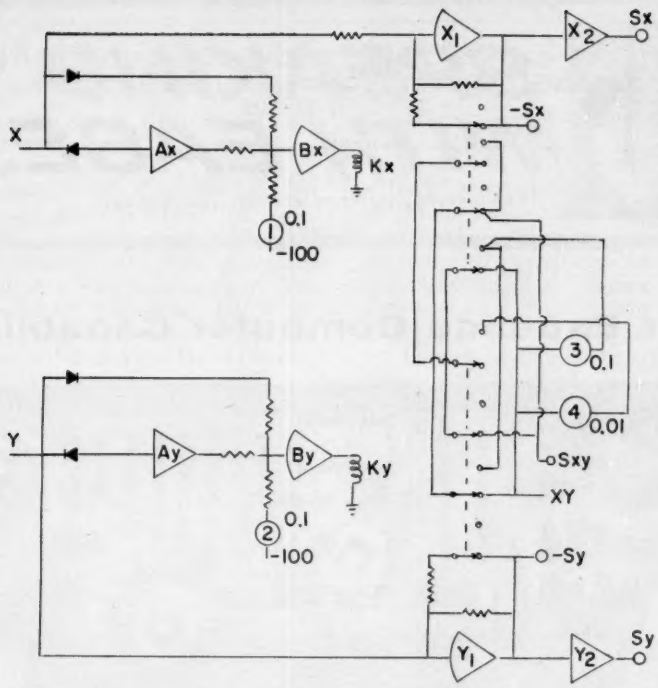


FIG. 2. TECHNIQUE for automatically changing scale to maintain multiplier accuracy.

tween the signal source and the multiplier. Simultaneously, a pot set to the load with a setting of one tenth is interposed between the multiplier's output and the device receiving the multiplier's output. A corresponding thing happens when "X_2" goes below ten volts. When both go below ten volts, both channels are active and an output pot set at one hundredth is interposed. This circuit causes the multiplying element to operate nearer full scale and reduces the error by factors of ten and one hundred. This improvement is gained at the expense of introducing switching transients. These effects can cause trouble, depending on the simulation.

CENTRAL SIMULATION COUNCIL MEETING OF 9 MAY 1961 ON OPERATORS, ADAPTIVE CONTROL, INDUCTION MOTORS, TRAPEZOIDAL CONVOLUTION AND SINGLE-INPUT-OUTPUT THEORY

Concerning the May 9th meeting of the Central Simulation Council Professor *Charles A. Halijak* (Kansas State University, Manhattan) writes: "The papers take up about 110 pages and they will require considerable condensation to be entered into your *Newsletter*. The Engineering Experiment Station of Kansas State University has kindly consented to publish the proceedings. Publication should start about July 15. I guess that copies would be available by August 15. Copies can be obtained from the Engineering Experiment Station when available."

Under the circumstances we will simply pass on to our readers the brief description of the papers which Professor Halijak sent:

"Simulation of the Fractional Derivative Operator $\sqrt{s}$ and the Fractional Integral Operator $\sqrt{1/s}$" by *Gordon E. Carlson* and *Charles A. Halijak* (Kansas State University)

"A cascade of 2^n symmetric balanced lattices approximates the characteristic impedance of the lattice in the sense of Newton's method. One can then use the driving point impedance of a cascade of a finite number of resistor-capacitor lattices to approximate $1/\sqrt{s}$ by means of an operational amplifier. Standard procedures then simulate any finite degree transfer function in $\sqrt{s}$. Such transfer functions are approximations to those occurring in transient diffusion problems."

"Analog Computer Study of an Adaptive Control for Closed-loop Systems" by *Charles H. Thomas* (University of Kansas)

"An adaptive controller is specifically needed in a control system when there are relatively large changes in gain and time lag. The system is designed so that the controller can maintain constant those factors which fix the relative stability of the system and the steady-state accuracy. The optimization criterion is linear minimum transient duration time."

"Electronic Analog Computer Representations of Induction Motors with Unbalanced Terminal Voltages" by *Paul C. Krause, Jr.* (University of Kansas)

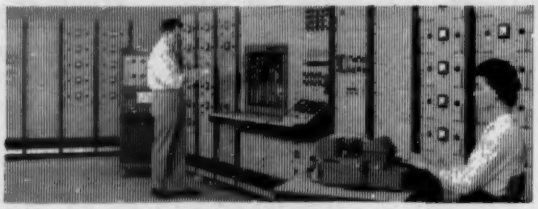
"Performance equations are developed and their computer set-ups are given for two-phase and three-phase induction motors with unbalanced applied voltages of any form. A comparison of exact and approximate representations shows that the transfer characteristic of a two-phase servomotor can be adequately represented with a less involved computer set-up."

"Digital Approximation of Differential Equations by Trapezoidal Convolution" by *Charles A. Halijak* (Kansas State University)

"An approximate Z-transform based upon trapezoidal quadrature is developed to solve a wide variety of differential equations. Particular attention is given to the recursive, integrator-substitution and differentiator-substitution programs for time-invariant systems. Upon this base, the solution of time-varying, continuous nonlinear, and discontinuous nonlinear differential equations can be easily constructed. The results of an empirical error analysis are given."

"A Theory of the Single-Input-Output Experiment" by *Philip G. Kirmser* (Kansas State University)

"A description is given of the response of a continuous nonlinear system to an arbitrary input in terms of its responses to a finite number of test functions. This theory exhibits a generalization of the principle of superposition, the inherent complexity of nonlinear problems, and a measure of nonlinearity for certain nonlinear systems."



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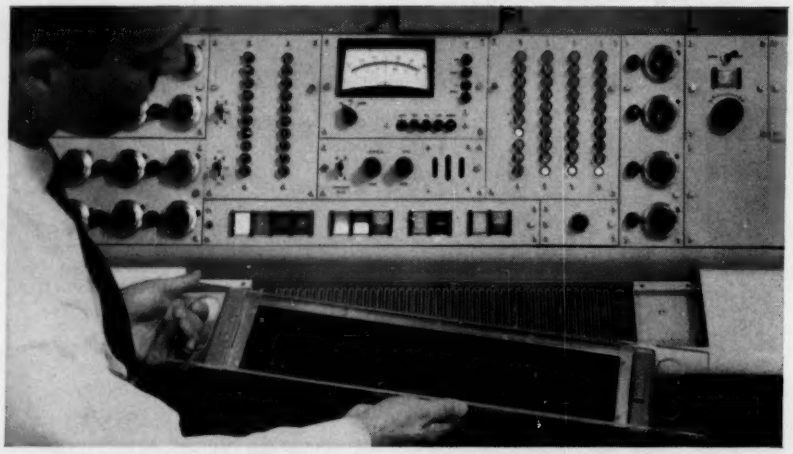
If you're curious as to exactly how much and what type of equipment can be used with IDA, literature is available on request.

**Trademark*



The control center of the IDA computer, showing removable pinboard with plexiglass cover.

and new flexibility...

Because the pinboard incorporates additional controls, you'll be amazed at the extreme latitude you have in setting up your problems. By just moving a pin you can change the function of an amplifier ... or override the master time scale. You can even program the master and slave clocks so the computer will iterate at different frequencies simultaneously.

and makes the job easier.

Computer operators will appreciate the convenience of having all the control functions right at their fingertips. Programming is accomplished simply by inserting the pins in position. Checkout is easier, too. On a conventional computer the patchboard is often loaded with a tangle of patchcords, making it difficult to trace out connections. On the IDA, patchcord clutter is minimized. Besides, no matter how complex the problem, the pinboard is always easy to read.

In addition, the board can be programmed either on or off the computer. If a programmed pinboard has to be carried or stored, the plastic top will keep the pins intact. When not in use, the pinboard – only 4¾" x 26¼" – can be stored in a relatively small, out-of-the-way place. If you wish, you can permanently record your programming on inexpensive overlays that fit directly onto the pinboard. These overlays are also available pre-programmed for checkout purposes.

This is the first edition of SPEAKING WITH EASE to deal with the new IDA iterative analog computer. Subsequent editions will discuss other aspects of this remarkable concept in analog computation.

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SOUTHEASTERN SIMULATION COUNCIL MEETING OF 14 APRIL 1961 ON SAMPLED-DATA CONTROL SYSTEMS AND DIODE BRIDGES

Thanks to Jim Toole we have the following information:

"The second meeting in 1961 of the Southeastern Simulation Council was held at the University of Alabama on 14 April 1961. Dr. *W. B. Stiles*, Professor and Head of the Engineering Mechanics Department, made all arrangements.

"Twenty-seven persons attended the meeting, and it should be noted that attendance seems to be slowly increasing.

"Four papers, as listed on the meeting announcement, were delivered at the morning technical session.

"The afternoon was devoted to demonstrations of an EAI TR-10, a Donner 3100, and a Heathkit computer. A question and answer period followed, which developed into an open discussion of applications for, and relative merits of, small computers."

Jim sent us copies of two of the papers, and said he had been trying (evidently without success) to get copies of the other two. Only his condensation, plus the author's conclusion, are given here because they sum up the subject very well.

Condensation of Sampled-Data Control Systems by Paul M. Julich (graduate student, University of Alabama)*

"A sampled-data control system is defined as a control system in which the signal data at one or more points in the system are in pulsed or digital form.

"The most important advantage of a sampled-data system is time sharing where one digital computer may control many different operations simultaneously. The primary disadvantage is that it leads toward instability.

"In the analysis of the system, the input and output to the sampler can be related by a polynomial in Z. A bilinear transformation may be made in which Z is replaced by:

$$Z = \frac{1 + w}{1 - w}$$

"The Bode plot and Routh stability criterion can then be used to analyze the system in the w plane.

"In addition, the sampler and zero order hold portions of the system may be approximated by a transport lag of one-half the sampling frequency, when the sampling frequency is at least five times the 6 db cutoff point of the open-loop transfer function.

"A sampled-data system can be simulated by using a high-speed mercury-wetted relay driven by a pulse generator for the sampler and the zero order hold. Some systems contain digital elements which are not easily simulated on the analog computer. For these systems, combined analog and digital simulation may be used.

"The importance of simulation in the analysis and design of sampled-data systems," the author concludes, "cannot be overlooked. Many of the methods used in analysis are quite laborious. Simulation provides a rapid means of determining the effect of parameter variations on the system. The study of non-linear effects in sampled-data systems is an outstanding example of the importance of simulation.

"Satisfactory means of analyzing non-linear systems are scarce and extremely tedious, whereas they may be easily simulated on the computer using the same techniques as are employed in continuous data control system simulation."

The other paper Jim sent, "Some Applications of Diode Bridges" by *James Spear* (Redstone Arsenal, Huntsville, Alabama), is presented in its entirety as it describes a unique packaging and application of some generally useful circuits.

*The copy of the paper that we got was ditto, so we assume additional copies can be obtained by writing the author c/o the University of Alabama, University, Alabama.

James Spear on Applications of Diode Bridges

The basic units to be discussed are the feedback limiter and the bridge limiter. We have constructed the simplest forms of the two units, encased them in the small plastic boxes that capacitors arrive in, and brought out four color-coded patchcords so the units may be connected directly to the patchboard.

The units have direct general applications as follows:

A. Limiting

B. Gating applications for simulating SPST and SPDT switches with the simulation of sequential operations as a goal.

C. The Simulation of Inelastic Stops

D. Simple Function Generation

The ideas for these applications, which led to the construction of these "boxes" and the subsequent discovery of their many uses came directly from:

(a) High Accuracy Electronic Switches for Analog Computation, **Walter Brunner, P. Landauer,** and **Arthur Rubin; Simulation Council Newsletter, Instruments and Control Systems,** May 1960, pages 384-385.

(b) Analog Computer Representation of Inelastic Stops, **Granino A. Korn, IRE Transactions on Electronic Computers,** p. 121 Volume EO-9, Number 1, March 1960.

Feedback Limiter

The *feedback limiter* is shown in Fig. 3.

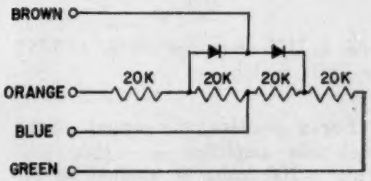


FIG. 3. FEEDBACK limiter.

Connecting the blue wire to an amplifier output, the brown wire to the amplifier grid, the orange wire to a negative voltage source and the green wire to a positive voltage yields the feedback limiter shown in Fig. 4.

FIG. 4. LIMITER "box."

This "box" is not too good as a limiter, especially for small voltages, because the 20K resistors still provide quite a noticeable gain factor. However, the unit was designed with the

gating applications in mind and has served quite adequately for that purpose.

Bridge Limiter

The *bridge limiter* is shown in Fig. 5. This unit has proven most useful

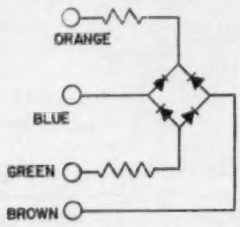


FIG. 5. **BRIDGE** limiter.

and new applications are being discovered every day, especially in the field of function generation.

A few examples will show how the feedback and bridge limiters may be applied. Fig. 6 shows use as SPST and SPDT switches.

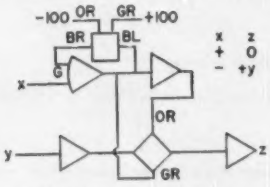


FIG. 6. **USE** of bridge limiter as SPST or SPDT switch.

For x positive, the output of the high-gain amplifier is —100 volts. This —100 volts is applied to the common plate junction of the diode bridge and +100 is on the common cathode junction. Thus, all the diodes are cut off and the z amplifier output is zero.

For x negative, the ±100 volt conditions are reversed, causing the diodes connected to the y amplifier to conduct and —y volts appears at both the common plate and common cathode junctions. If y is positive, —y is negative and current flows through the common cathode junction and the z output is positive = +y. If y is negative, current flows through the common plate junction and the z output is negative = +y.

Of course the y voltage is limited to roughly ± 98 volts because of the resistors connected to the control amplifiers.

Measurements of the error between z and y for the switch being "on" shows approximately 0.25 volt maximum error due to the diode characteristics. The maximum error occurs at the 98-volt level and decreases rapidly as y approaches zero.

This error can be decreased to roughly 2.5 mv. at the expense of patching a feedback limiter around the y amplifier (Fig. 7).

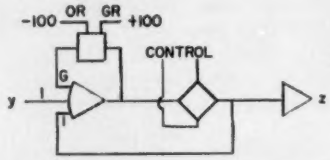


FIG. 7. **USE** of feedback limiter around y amplifier decreases error.

This arrangement makes the total gain from y to z independent of the diode characteristics while the switch is "on" and the limiter protects the y amplifier when the switch is "off."

To simulate a SPDT switch, connect two bridge limiters, both controlled by the same x value but arranged so they conduct for opposite signs of x (Fig. 8).

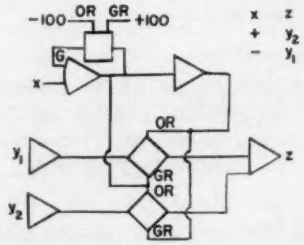


FIG. 8. **USE** of two bridge limiters to simulate a SPDT switch.

Inelastic Stop

The *Inelastic Stop* is shown in Fig. 9. Required: When x reaches a limit $\dot{x} = 0$ and then be able to "back off."

When x reaches either limit the appropriate control amplifier "shorts" the feedback of the $\dot{x}$ amplifier and discharges the capacitor until $\dot{x}$ changes sign. While x is between its limits, the bridge is "open" and the $\dot{x}$ amplifier is a normal integrator (Fig. 10).

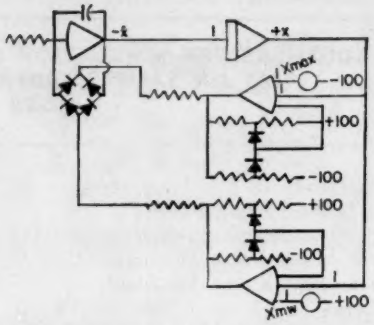
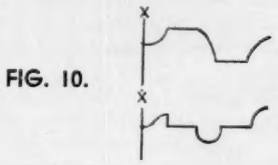


FIG. 9. **INELASTIC** stop.



This method of limiting is applicable whenever the derivative of the function to be limited is explicitly generated. This method, combined with the switching applications, has been used in the simulation of sequential operations on a computer model of a rocket engine. The inelastic-stop type of limiting kept several integrators shut off until certain conditions were met. These operations were later programmed using ten DPDT relays which were not available when the problem was begun.

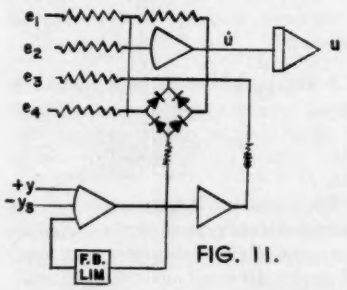


FIG. 11.

Simple Bridge Limiting and Function Generation

Fig. 12 is a perfect "hard" limiter and can be made independent of the

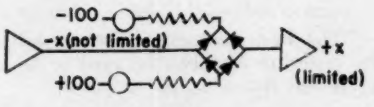


FIG. 12. **HARD** limiter.

diode characteristics as was shown in the switching applications.

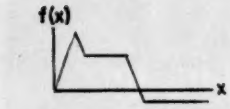
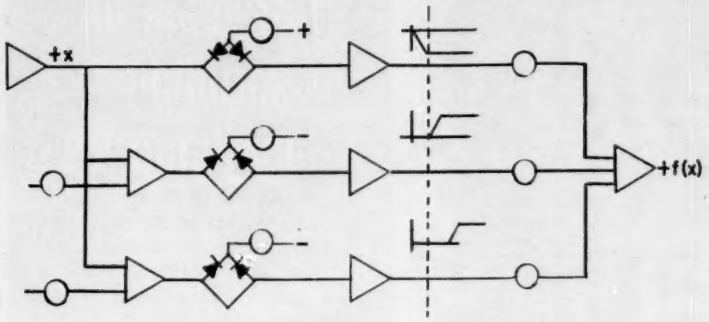


FIG. 13. FUNCTION generation.

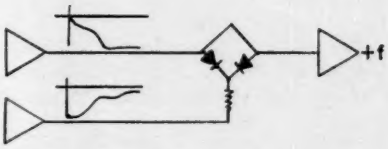


Some simple functions can be generated using several bridges in parallel. Because of the limiting action, the function segments can be made independent of each other (Fig. 13).

By applying a varying voltage as the limiting action we can obtain functions similar to Fig. 14.

The output function is simply the smaller of the input functions.

FIG. 14.



ANALOG TECHNIQUES BY THOMAS C. ANDERSON (LOCKHEED MISSILES AND SPACE DIVISION, SUNNYVALE, CALIFORNIA)

Setting Integrator Capacitors

A common problem in all analog computing installations is the setting of the integrator capacitors. If they are not set to produce equal integrator time-constants of value unity, serious inaccuracies in the solution will be encountered. If the values are not matched, each integrator will operate at a different rate, and if the values are matched but not equal to unity, a spurious time scaling will result. The magnitude of both of these effects increases linearly with time, which can cause considerable trouble in problems requiring long runs.

A method of setting precision computing capacitors was devised by Mr. *C. J. Sheehan* of Lockheed Missiles and Space Division, Sunnyvale, California. It has the advantage of matching the capacitors to the resistors through time measurements. Since it is possible to measure both resistance and time quite accurately, the capacitors can be set more precisely than with any of the standard bridge techniques.

Method

Consider three integrators 1, 2 and 3. Assuming the input resistors are within 0.1% of their design values and for each integrator matched to 0.01% and also the availability of a perfect inverter, any number of integrator capacitors may then be set from just one of these integrators.

Set up a standard sine-cosine oscillator with frequency of one radian per second using integrators 1 and 2 as shown in Fig. 15. Cross-talk and

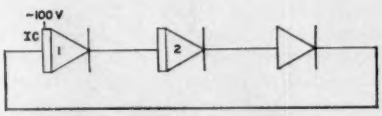


FIG. 15. SINE-COSINE oscillator.

imperfections will, in general, result in either damping or divergence of the oscillations, but at this frequency it should be undetectable for the number of cycles under consideration.

Using an electronic counter the period is then read and recorded, as are the periods of the other two combinations of integrators, 1 and 3, and 2 and 3. The gain of each integrator is $1/RC = 1/T$. The equation defining the frequency of oscillation in radians per second is

TOM ANDERSON

ω^2_{12} = loop gain

$$\omega^2_{12} = \left(\frac{1}{R_1C_1}\right)\left(\frac{1}{R_2C_2}\right)\left(\frac{R_F}{R_I}\right)$$

$$\omega^2_{12} = \left(\frac{1}{T_1}\right)\left(\frac{1}{T_2}\right)\left(\frac{R_F}{R_I}\right)$$

$$\omega^2_{12} = \left(\frac{1}{T_1T_2}\right) \text{ when } \frac{R_F}{R_I} = 1$$

Then the equations for the three combinations of integrators are

$$\omega^2_{12} = \frac{1}{T_1T_2} \quad (1)$$

$$\omega^2_{13} = \frac{1}{T_1T_3} \quad (2)$$

$$\omega^2_{23} = \frac{1}{T_2T_3} \quad (3)$$

We have three equations in three unknowns and can therefore solve for the three T's obtaining

$$T_1 = \frac{\omega_{23}}{\omega_{12}\omega_{13}} \quad (4)$$

$$T_2 = \frac{\omega_{13}}{\omega_{12}\omega_{23}} \quad (5)$$

$$T_3 = \frac{\omega_{12}}{\omega_{13}\omega_{23}} \quad (6)$$

Since

$$P_{ij} = 2\pi\omega_{ij} \quad (7)$$

$$T_1 = \frac{P_{12}P_{13}}{2\pi P_{23}} \quad (8)$$

$$T_2 = \frac{P_{12}P_{23}}{2\pi P_{13}} \quad (9)$$

$$T_3 = \frac{P_{13}P_{23}}{2\pi P_{12}} \quad (10)$$

where P_{12} = period of oscillation using integrators 1 and 2.

Thus, knowing the periods, we can calculate the value of any one of the integrator gains as follows:

Assume we solve for T_2 and then wish to adjust C_3 to make $T_3 = 1$. From (3):

$$\omega^2_{23} = \frac{1}{T_2T_3} = \frac{1}{T_3} \text{ when } R_3C_3 = 1.$$

Since $\omega_{23} = \frac{2\pi}{P_{23}}$, we have

$$\frac{1}{T_2} = \frac{4\pi^2}{P_{23}^2} \text{ when } RC = 1. \quad (11)$$

$$P_{23} = 2\pi\sqrt{T_2} \text{ when } R_3C_3 = 1. \quad (12)$$

With integrators 2 and 3 in the loop, we adjust C_3 so that the period reads $2\pi\sqrt{T_2}$. This sets $T_3 = R_3C_3 = 1$. Placing any other integrator in the loop with integrator 3 and adjusting its capacitor until the period is 2π will match its capacitor to the input resistors also.

SCI Activities

As of July 14th*, the 400th person to pay his $3 "and meet certain other requirements" became a member of SCI. Who? Well, who else but ye Ed!

I had wanted to be first but *Bill Schart* was too fast for me. So, being in a position to influence our Treasurer (!) I managed to get my $3 counted at the correct time to be the 400th member and therefore—with 399 others—qualify SCI for membership (insofar as the number of registered members is concerned) in the American Federation of Information Processing Societies.

But don't you who have not yet registered let this deter you from doing so. We still need you; the more bona fide members the stronger our position in national and international "*affaires de computeur.*"

Besides: (a) Membership will assure you of receiving your monthly copy of this excellent (sic) *Newsletter* handsomely bound between the protective covers of *I&CS*.

(b) You will be qualified to vote and thus have a voice in the affairs of the regional Simulation Council of your choice.

(c) You will help that Simulation Council financially, as the kick-back from SCI to the local Councils is based on the registered membership of that Council.

REPORTS RECEIVED—MEETINGS TO BE COVERED

The Midwestern Simulation Council of May 15th at Rock Island Arsenal on "Advertising Our Wares—The problem of educating working engineers and management on the capabilities of, and methods of formulating problems for, analog computer installations."

The panel which discussed the subject included *Milt Warshawsky, A. I. Katz, William B. Field, Ralph J. King,* and *Bob Howe.*

The Rocky Mountain Simulation Council on June 27th in Denver, including brief resumés of the following:

"A Free Turbine Engine for Helicopter Applications" by *George Brown;* "The Simulation of Static and Frictional Forces" by *John Zampino;* and "Determination of True Input" by *Maughan Mason.*

*Formerly best known as Bastille Day

INFORMATION (Without Theory)

Invitation for Papers

This is the first call for papers for the 1962 Spring Joint Computer Conference, to be held in San Francisco, California, on May 1, 2, 3, 1962. This Conference is the direct successor to the Western Joint Computer Conferences of previous years. The new name reflects the change in designation from location reference to time reference, and is correlated with our new sponsoring organization, the American Federation of Information Processing Societies (AFIPS).

This Conference Committee has decided to dispense with an official theme or slogan. But the implicit theme remains. The objective is, as always—to publish, distribute, present, and discuss new and significant information on achievements, trends, concepts, and techniques in the computer field and allied areas.

Evaluation of the submitted papers will be based on a review of the *complete preliminary draft* of each paper. We request that the paper be complete, to enable full consideration of the technical content. However, as a preliminary draft, the text and drawings need only be clear and readable, not necessarily formal or artistic.

To enable adequate review of your paper, and to permit distribution of the Conference Proceedings at the time of registration, please submit three copies of your paper to the Technical Program Committee as soon as possible—by November 10, 1961, at the latest. The papers will be reviewed, final selection made, and authors notified by early January.

There will be several sessions devoted exclusively to analog and hybrid computers and techniques, provided a sufficient number of *high-quality* papers are submitted.

He Went Thataway!

Ted Kusto to Analog General Corporation, 7-11 Main Street, East Rockaway, Long Island, New York.

We have a card to the effect that *Ben Clymer* is now a consulting analytical engineer "specializing in the development and application of computer simulations for the design and analysis of dynamic systems and processes." Ben's address is 1672 Barrington Road, Columbus 21, Ohio.

Letters

John:

While I was talking to Paul Roth at the Midwestern Simulation Council meeting, he said he would like to find more info on how to simulate power supplies in systems with a lot of circuitry. I said an "anonymous inquiry" in the *Newsletter* might produce the lead because others have had the problem. How about a "Reader Inquiry" section in the *Newsletter?*

Milt.

Anyone else for this idea?—Ed.

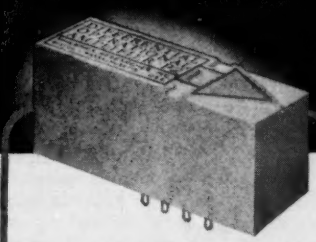
Dear John:

We have just completed a research program for the U. S. Naval Training Device Center on the use of combined analog-digital computers for real-time simulation with emphasis on the aircraft model employed in Operational Flight Trainers. A copy of our final report to the Center is enclosed.

In view of the widespread activity on hybrid computing techniques at the present time, perhaps some of the Simulation Council members would be interested in knowing about this report. We have a few extra copies here at M.I.T. and, presumably, the U. S. Naval Training Device Center at Port Washington, N. Y. will be making copies available to qualified petitioners.

Mark E. Connelly
Electronic System Laboratory
Massachusetts Institute of Technology
Cambridge 39, Mass.

The all-new, all solid-state Philbrick P2 amplifier



NO TUBES, NO CHOPPERS, NOTHING BUT PERFORMANCE. An ingenious arrangement of all solid-state components endows this operational amplifier with the most remarkable and versatile characteristics. *Full differential input:* truly floating with respect to ground. *No common mode error. Low input current:* typically 10^{-11} amps. *Low noise:* typically under 10 microvolts in the dc to 1 kc range. *Sub millivolt long term stability:* less than 100 microvolts drift per day. *Cool running:* typically under 330 milliwatt dissipation. *Wide band pass:* typically under 75 kc as a unity gain follower. *High open loop gain:* typically 30,000. Its output delivers 1 ma at ± 10 volts. The cast aluminum housing fits right in your hand.

Use the P2 for instrumentation, analog computation, and other applications requiring high reliability and accuracy. Take advantage of its differential inputs to perform high impedance operations. *Truly low cost:* **$210.**

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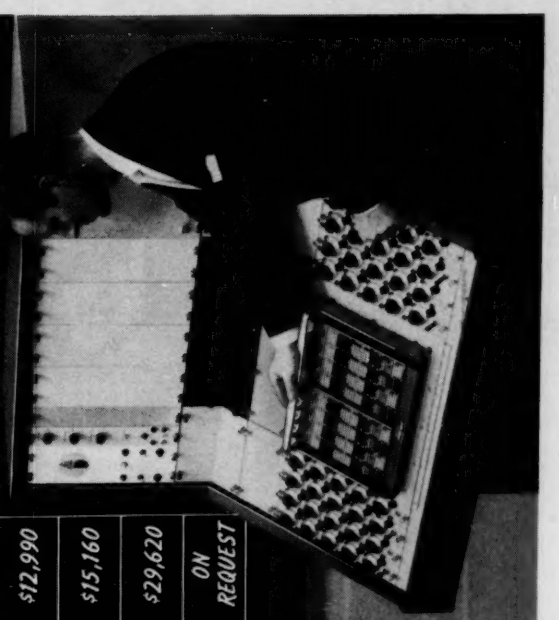

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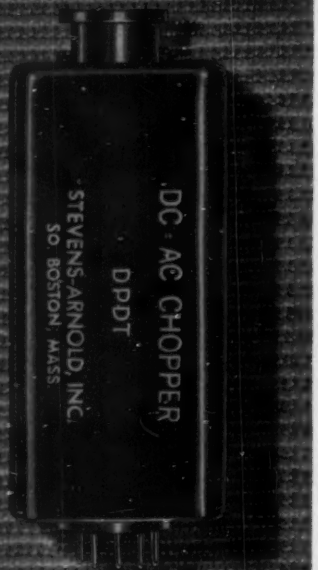
NEW

TWIN CONTACT MINIATURES



DC-AC CHOPPERS

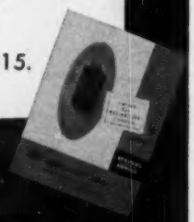
Eleven types, both single and double pole.

Long life.

Low noise level.

Extreme reliability.

Write for Catalog 515.



STEVENS INCORPORATED ARNOLD

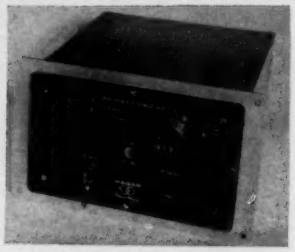
7 ELKINS STREET
SOUTH BOSTON 27, MASS.

S/A-14

CIRCLE 106 ON READER-SERVICE CARD

I&CS NEW INSTRUMENTS

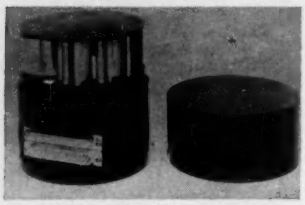
MILLIVOLT REFERENCE BOX



New millivolt Reference Box provides precise suppression voltage or controller set point for high temperature process control applications or can be used to evaluate temperature measuring and control equipment. Operates in 0-20-mv range with three overlapping ranges of 10 mv each. Zener regulated voltage is used as supply reference.—*Hagan Chemicals & Controls, Inc., Hagan Center, Pittsburgh 30, Pa.*

CIRCLE 240 ON READER-SERVICE CARD

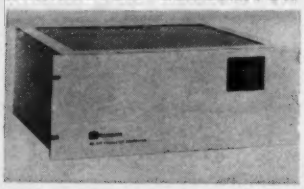
MINI TAPE RECORDER



New Model TR-1875 3½ lb, 4¼" dia x 4¾" long magnetic Tape Recorder simultaneously records data (1 to 14 channels, in line or interlaced) from test conducted under severe environmental and limited space conditions. Available in speeds of 1.875, 3.75, 7.5 and 15 ips with capacity of 150' of 1-mil tape, providing up to 16 minutes recording.—*Aero Data Corp., Div. American Concertone, Inc., 9449 W. Jefferson Blvd., Culver City, Calif.*

CIRCLE 241 ON READER-SERVICE CARD

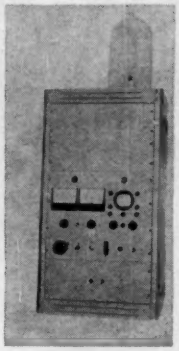
CHARACTER GENERATOR



New TD-549 Character Generator displays up to 100,000 characters/sec, "prints" over million words/min in any "alphabetic" language. Features extreme flexibility with 64 plug-in characters and codes, technical symbols, upper and lower case characters, etc.—*Transdata, Inc., Box 1369, San Diego 12, Calif.*

CIRCLE 242 ON READER-SERVICE CARD

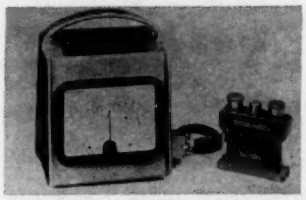
D-C CORONA TESTER



New Model 5435 D-C Corona Test Set has 20-kv corona-free d-c high voltage supply, corona pickup filter network, and corona detector; displays voltage pattern on built-in oscilloscope. Vacuum bell-jar and table mounted at top of cabinet are evacuated by internally mounted vacuum pump, allowing simulated high altitude testing of insulating materials, cables, components and assemblies.—*Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.*

CIRCLE 243 ON READER-SERVICE CARD

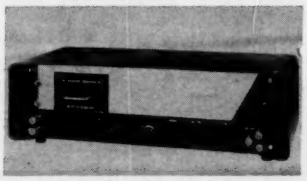
ELECTRONIC LEVEL



New battery-operated Talyvel Electronic Level uses pendelum and pair of variable inductance transducers which provide electrical displacement signal amplified to feed center-zero meter. Can determine sway of structures, machines, etc. Unit mounts inside enclosure, on high structure, or up to 300' from level unit.—*Engis Equipment Co., Div. Engineering and Scientific Instrumentation, 431 S. Dearborn St., Chicago 5, Ill.*

CIRCLE 244 ON READER-SERVICE CARD

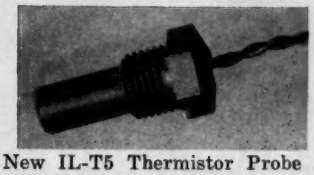
LOG FREQUENCY CONVERTER



New Model HLFC-120 Log Frequency Converter provides d-c voltage output which varies in proportion to logarithm of frequency of input signal from 0.5 to 100 v. High harmonic content does not affect accuracy. Features interchangeable plug-in Log Frequency Discriminator networks with 1, 2, or 3 decade ranges from 5 cps to 20 kc, 2% accuracy for 3 decade ranges.—*Houston Instrument Corp., Box 2234, Houston 27, Texas.*

CIRCLE 245 ON READER-SERVICE CARD

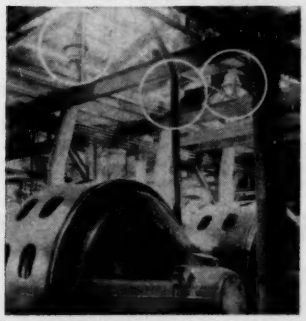
THERMISTOR PROBE



New IL-T5 Thermistor Probe Assembly for fluid measurement and control has range of −40° to +265°F. Molded of epoxy resin, installed in standard ¼" pipe thread fitting, it has resolution better than 0.01°F and time constant of approximately 5 sec. Nominal resistance is 36.4 ohms at 212°F, 364 ohms at 100°F, 649 ohms at 77°F and 1448 ohms at 32°F.—*Instrumentation Lab.*, 108 *Commington St., Boston, Mass.*

CIRCLE 246 ON READER-SERVICE CARD

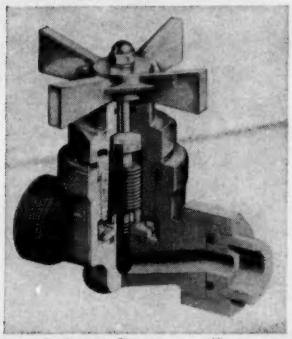
PULP CONTROL VALVE



New flow control valve shaped like a variable venturi with smooth entrance and exit areas, eliminates pulp build up and corrosion problems. Valves can be remotely controlled from convenient station at the refiner. —*Clarkson Co.*, 735 *Loma Verde Ave., Palo Alto, Calif.*

CIRCLE 247 ON READER-SERVICE CARD

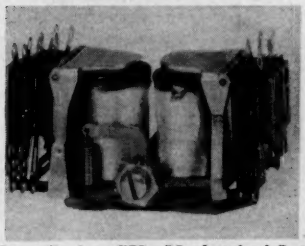
LEAKPROOF VALVES



New O-Seal System offers proved leakproof flexibility for handling liquids and gases at pressures to 6000 psi. Heart of valve is resilient nylon disc which deforms and assumes surface of metal seat, assuring positive valve shut-off. Self-sealing union with "O"-ring recessed in tail-piece assures leaktight connection even when union nut is only tightened by hand. Bulletin.—*Combination Pump Valve Co.*, 846 *Preston St., Phila.* 4, *Pa.*

CIRCLE 248 ON READER-SERVICE CARD

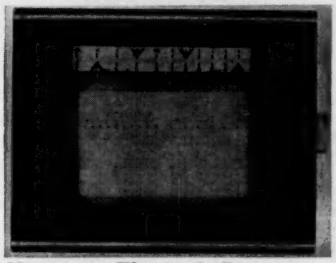
INTERLOCK RELAYS



New Series SIL Mechanical-Interlock Relay and Series SEL Electrical-Interlock Relay are bi-stable and indefinitely hold an armature operated. Comprised of two miniature Class-S relays mounted on a common base. When a relay is energized, armature is locked in operate position by mechanical linkage. Series SEL has same configuration as SIL except that mechanical linkage is omitted. SEL is wired so that both relays are controlled by pulsing over a single lead. —*Automatic Electric Sales Corp., Subs. of General Telephone & Electronics, Northlake, Ill.*

CIRCLE 249 ON READER-SERVICE CARD

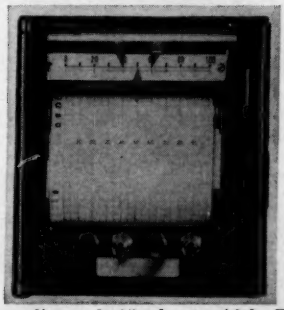
RECORDER



New 4-pen Electronic Dynamaster® Recorder compares four simultaneously recorded variables on a time basis. Records any set of variables that can be transduced into electrical quantity. Each pen has own motor driven balancing unit.—*Bristol Co., Waterbury* 20, *Conn.*

CIRCLE 250 ON READER-SERVICE CARD

TELEMETER RECEIVER



New line of 4" chart-width Telemeter Receivers Series 670 fits any Metameter® telemetering system. One or two pens available with one or two retransmitting slidewires and maximum of four individually adjustable alarm contacts.—*Bristol Co., Waterbury* 20, *Conn.*

CIRCLE 251 ON READER-SERVICE CARD

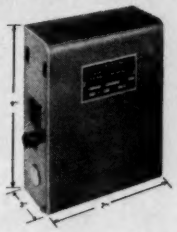
Stewart Ashton, our Chief Engineer, reports on the all-new . . .

pHayes-master (TM)

HERE AT LAST is a simple, compact, space-saving package that provides *microsecond* response for controlling power to electric furnaces . . . and *for numerous other applications* and processes where temperatures must be precisely regulated.

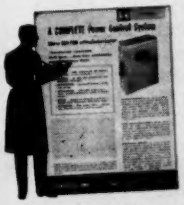
A TRANSISTORIZED UNIT, the new Hayes pHayes-master now replaces costly and bulky saturable core reactors, tubes, magamps, powerstats, etc. — with *one*, small, smartly-designed control unit!

VERSATILE, TOO . . . pHayes-master can be used with most proportioning type temperature instruments . . . handles up to 70 amp. capacities at 220 volts, with stepless control over the full 0-100% range. Highly accurate, pHayes-master provides instantaneous, straight-line response . . . completely without lag or hunting.



ECONOMY is another big advantage. The Hayes pHayes-master features a high power factor—expends only a fraction of the power source for control. Simple rugged construction and circuitry make it far easier and cheaper to install and maintain than conventional control devices.

These are just the highlights. If *your* equipment or process calls for close control of power for heat generation, get the *complete* facts on the all-new Hayes pHayes-master. Write for new Bulletin C-1,or tell us about your application requirements. — C.I.HAYES, INC., 944 Wellington Ave., Cranston 10, R. I.



C. I. HAYES, INC.

Established 1905

It Pays To See Hayes for metallurgical guidance, lab facilities, furnaces, atmosphere generators, gas and liquid dryers, pHayes-master (TM) control units.

CIRCLE 107 ON READER-SERVICE CARD

KENDALL/GOVERNAIRE

SEND FOR CATALOG ON

PRECISION AIR REGULATORS

Large balanced supply and relief valves provide rapid response with precise control plus maximum flow for minimum size.

Kendall is a direct acting, spring actuated, bleed type valve. Governaire is pilot assisted. Both lines have a unique boost action with increased flow rate that offsets downstream pressure losses. Both are immune to supply pressure variations and suited to either high-flow or dead-end applications. With the Kendall/Governaire lines, Stratos offers the largest selection of standard and special precision pressure regulators, relays and volume boosters in the industry.

For your copy of the Stratos Engineering Manual and Data Sheets illustrated above, write

STRATOS®

A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

Bay Shore, L. I., N. Y.

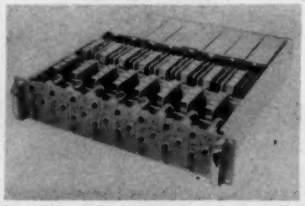
CIRCLE 108 ON READER-SERVICE CARD

TAPE COMPARATOR

New line of Tape Comparator Systems insures accurate and speedy verification of tapes and duplication of tapes and edge cards comparing 5-, 6-, 7-, or 8-bit codes primarily for computer and numerical systems application. Choice of eight systems including comparator systems, regeneration systems, and combination of both.—*Friden, Inc.*, 97 *Humboldt St., Rochester* 2, *N. Y.*

CIRCLE 252 ON READER-SERVICE CARD

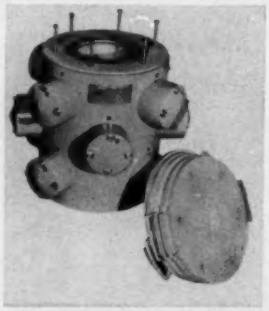
STRAIN-GAGE SIGNAL CONDITIONER



New line of strain-gage signal conditioning equipment includes SSC-1 initial production model. 8-channel unit features any configuration of bridge circuitry (1-, 2-, 3-, or 4-active arms); up to four calibration points; single and double shunt; plus or minus and plus and minus calibration, and modularized construction with each channel contained on 3 printed-circuit plug-in cards.—*Astra Technical Instrument Corp.*, 12930 *Panama St., Los Angeles* 66, *Calif.*

CIRCLE 253 ON READER-SERVICE CARD

SCINTILLATION WELL COUNTER



New large Well Counter Model 90-2 measures low amounts of radioactivity in any given sample, has sensitivity of 10-10 Curies of K-40 above background with 20-min count. Detector consists of plastic scintillation well counter (24" x 12" dia) with 5" steel shielding. Circuitry consists of 12 DuMont 6363-3" multiplier phototubes.—*Franklin Systems, Inc.*, 2734 *Hillsboro Rd., West Palm Beach, Fla.*

CIRCLE 254 ON READER-SERVICE CARD

SPOT CRITICAL TEMPERATURES ACCURATELY with

NEW PYRO MICRO-OPTICAL PYROMETER

All-purpose PYRO Micro-Optical precisely measures targets as small as .001" in diameter or objects at remote distances to 2°C reproducibility! Temperature scales 700° - 3200°C (1300° - 5800°F).

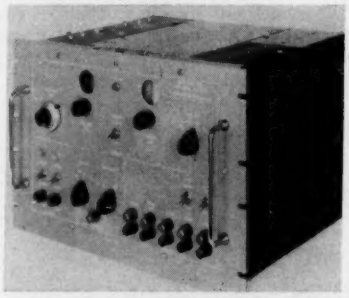
Send for FREE catalog No. 95.

PYROMETER INSTRUMENT CO., INC.

BERGENFIELD 4, NEW JERSEY

CIRCLE 109 ON READER-SERVICE CARD

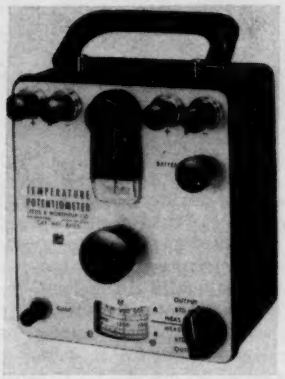
SERVO ANALYZER



New Model 900 series SERVODYNE all electronic servo analyzer provides direct reading phase and amplitude measurements vs. frequency for electronic, electro-mechanical, or mechanical servo systems. Three frequency models; 0.1 to 100 cps; 0.01 to 100 cps; and 0.001 to 100 cps, with sine wave or square wave modulated or unmodulated output. Equipment provides internal carrier with 20-watts output to operate servo system components, also operates from external carrier of 45 to 4600 cps. Special units can be provided with carrier and modulation frequencies up to 20 kc. Accuracies: frequency, 2% of decade range; amplitude, 2% of full scale; and phase, ±1°.—*Remanco, Inc.*, 1805 *Colorado Ave., Santa Monica, Calif.*

CIRCLE 255 ON READER-SERVICE CARD

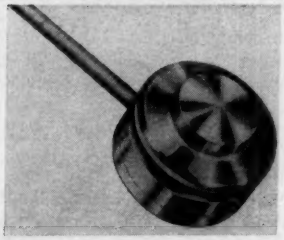
POTENTIOMETERS



New 8694 Single-Range and 8695 Double-Range Temperature Potentiometers indicate temperatures in °F in any of 15 ranges. New 8696 Double-Range Millivolt Potentiometer is calibrated for emf measurements on two ranges, 0 to 22 and 20 to 64. Manual reference junction compensation dial can be used as source of calibrated voltage for checking other potentiometer-type instruments.—*Leeds & Northrup Co.*, 4934 *Stenton Ave., Phila.* 44, *Pa.*

CIRCLE 256 ON READER-SERVICE CARD

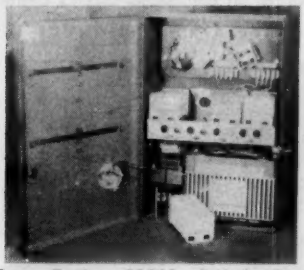
LOAD CELL



New Load Cell, Type BL-1, employs precisely-machined stainless steel bellows coupled inductively to ultra-sensitive differential transformer. Hysteresis error less than 0.1%; temperature, −85° to +500°F; in ranges from 5 to 500 lb.—*United Aero Products Corp., Burlington, N. J.*

CIRCLE 257 ON READER-SERVICE CARD

CODED TRANSMITTER PANEL

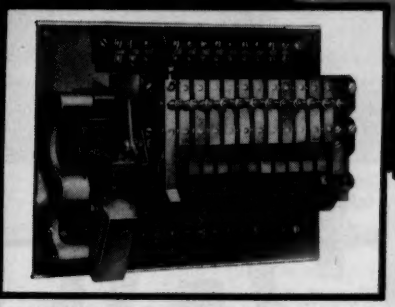


New Series MCN Coded Transmitter Panel meets general government specs for automatic fire detection and alarm systems. Coded signals are shunt non-interfering and allow MCN panel to be connected to most standard coded systems. Unit permits 6 different basic performances by changing plugs.—*Notifier Corp.*, 3700 *N. 56 St., Lincoln* 4, *Neb.*

CIRCLE 258 ON READER-SERVICE CARD

A BASIC CONTROL IDEA

as simple as 1+2=3



DESIGN YOUR NEXT MACHINE OR PROCESS CONTROL CIRCUIT THIS EASY WAY

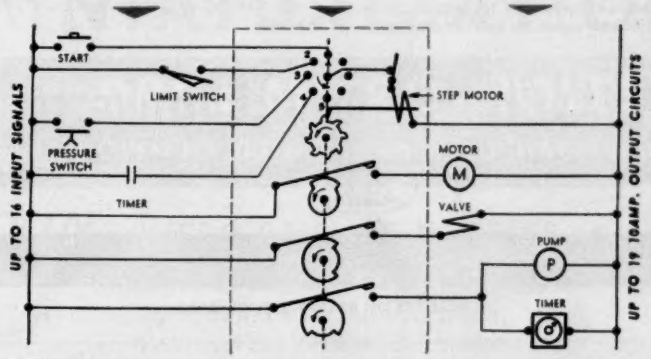
Start with THE BULLETIN 780 STEP SWITCH FOR STEP-BY-STEP SEQUENCE CONTROL

1 INPUT SIGNALS + 2 BULLETIN 780 STEP SWITCH = 3 PROGRAMMED SEQUENCE CONTROL

Closure of a control device, actuated upon completion of an operation, advances control to next position.

Circuits are opened or closed at each position or step according to preselected cam action.

Loads are interlocked thru step switch cams without complicated relay circuitry.



Write for Bulletin 780 or call your local Representative. He's listed in Sweet's Product Design File, Section 7d/EA, or in Thomas Register.

Precision Interval Timers | Plug-in Reset Timers | Multiple Circuit Timers | Multiple Cam Timers | Predetermined Counters | Hermetically Sealed Timers

MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS AVAILABLE

BLISS

EAGLE SIGNAL COMPANY • Moline, Illinois

INDUSTRIAL DIVISION

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CIRCLE 110 ON READER-SERVICE CARD

In Use Throughout the World

Daniel Flangnek Standard Meter Tubes feature factory aligned upstream tubes *guaranteed free of offsets.* Standardized tubes offer savings in ordering and installation time, and assure you of constant uniformity every time. The tubes are stocked complete with the popular Senior Orifice Fitting or the economical Simplex Plate Holder, one ¾" and two ½" couplings, and a stainless steel orifice plate bored to customer specifications. Ordering is easy. Just furnish us the following information:

(1) Size, (2) Catalog Number, (3) Plate Bore.

Send for your free copy of our Meter Tube Catalog Section "D."

DANIEL ORIFICE FITTING CO.

HOUSTON PLANT
9720 Katy Road, Houston 24, Texas

LOS ANGELES PLANT
3352 Union Pacific Ave., Los Angeles 23, Calif.

CIRCLE 111 ON READER-SERVICE CARD

GALVANOMETER PROTECTOR

New Galvanometer Protector prevents coil burnout of magnetically damped galvanometers, utilizes replaceable insert which permits repeated use of protector. Unit attaches to existing galvanometer input panels, requires no change in existing damping resistor networks. Insertion resistance is 4 ohms nominal at 75°F; parallel resistance, greater than 7.5 k ohms for input signals of ±100 mv or less; phase shift, 1° maximum from 0 to 10 kc.—*Consolidated Electrodynamics Corp., Subs. Bell & Howell, 360 Sierra Madre Villa, Pasadena, Calif.*

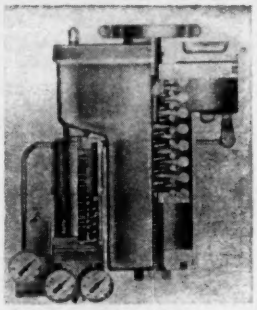
CIRCLE 259 ON READER-SERVICE CARD

FREQUENCY-TO-DC CONVERTER

New airborne Frequency-to-dc Converter Model FR-84 for telemetering flow and tachometer data features solid-state circuitry on printed circuit cards and is qualified for 100-G shock and 20-G vibration. Provides 0-5 v dc output with ±0.25% linearity, overrange limiting at 6.8 v, power consumption of 45 ma at 27.5 v, sensitivity adjustment and rolloff circuitry to provide inverse gain-to-frequency circuit for maximum noise rejection. —*Waugh Engineering Div., Foxboro Co., 7842 Burnet Ave., Van Nuys, Calif.*

CIRCLE 260 ON READER-SERVICE CARD

PNEUMATIC VALVE ACTUATORS



New Series P Pneumatic Positioning Actuators with position accuracy of 0.1% of stroke, completely adjustable from outside, are furnished in either air-to-open or air-to-close with fail-open or fail-closed action. Patented positioner pilot valve alters output pressure to bottom of piston. Rangeability is 50:1 or more; split ranges available.—*Security Valve Co., 909 El Centro St., South Pasadena, Calif.*

CIRCLE 261 ON READER-SERVICE CARD

DESK-SIZE COMPUTER

New Operator Console for E103 desk-size electronic digital computer houses 10-total typewriter accounting machine and printer. Has alphanumeric capability. Console is cable-connected to master unit.—*Burroughs Corp., Equipment & Systems Div., Detroit 32, Mich.*

CIRCLE 262 ON READER-SERVICE CARD

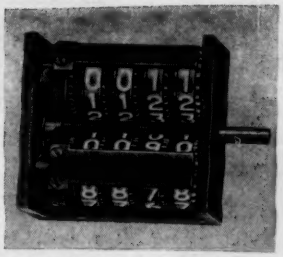
10-MC COUNTER-TIMER

New Model 365RP Remotely-Programmable 10-Mc Counter-Timer in Apti-Meter line features transistorization, self-contained functional circuitry, modular, plug-in printed-circuit construction, in-line Nixie readout, etc. Operates in nine different functional modes and performs complete measurement in time-frequency domain. Totalizes random events from 0.1 μsec to 10 sec, or counts continuously with capacity of 9,999,999. Measures time interval from 0.1 μsec to 10 sec, frequency from 0.1 to 10,000,000 cps, period from 0.1 to 10^8 sec, etc.—*Transistor Specialties, Inc., Terminal Dr., Plainview, L. I., N. Y.*

CIRCLE 263 ON READER-SERVICE CARD

COUNTER

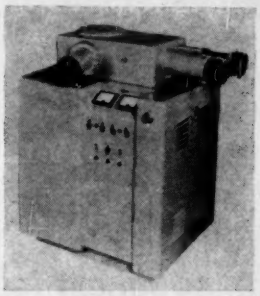
New dual-bank Counter Model 4-4-Y-9425-R-AC for plus and minus, right and left, or directional readings features both banks open for reading at zero position. When passing zero position, one bank is shuttered and other bank adds. When reversed thru zero position, shuttered bank opens



and other bank is closed. Bulletin B-508.—*Durant Mfg. Co., Milwaukee, Wis.*

CIRCLE 264 ON READER-SERVICE CARD

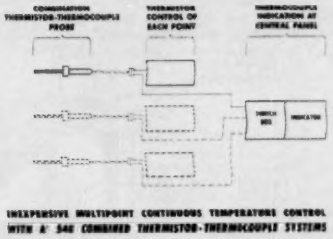
VACUUM MONOCHROMATOR



New vacuum U. V. Scanning Monochromator Model 230-S features dispersing element with 600-line/mm, 4"-dia grating, entrance and exit slits rotatable from outside of vacuum chamber, 12 reversible scanning speeds from ½ to 2000 A/min useful range from 500 to 5461 A, resolution with standard grating of ½ A, vacuum better than 5×10^{-6}.—*McPherson Instrument Corp., Acton, Mass.*

CIRCLE 265 ON READER-SERVICE CARD

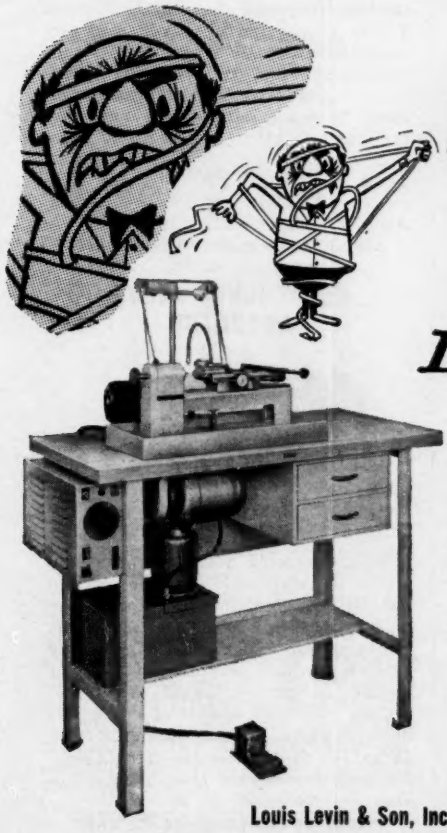
TEMPERATURE MONITORS



INEXPENSIVE MULTIPOINT CONTINUOUS TEMPERATURE CONTROL WITH A+ 540 COMBINED THERMISTOR-THERMOCOUPLE SYSTEMS

New A+ 540 Thermistor/Thermocouple system for continuous process temperature control at various locations with indication at a central point consists of three main elements: probes, thermistor controls, and potentiometric indicator. Each probe contains thermistor sensor ond thermocouple. An inexpensive transistorized temperature controller, or alarm module, is permanently connected to each thermistor sensor. Thermocouple leads from each probe are brought to central switchbox and then to potentiometric indicator.—*Atkins Technical Inc.*, 1276 *W. 3rd St., Cleveland* 13, *Ohio.*

CIRCLE 200 ON READER-SERVICE CARD



ARE YOU PROPERLY GEARED FOR

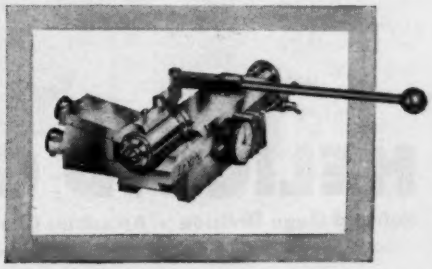
MINIATURIZATION?

DRILL MICRO-HOLES

DOWN TO .0016" with SPEED & ACCURACY

LEVIN ® MICRO-DRILLING MACHINE

Designed for the most precise drilling of small holes. The drilling spindle, as well as the head stock spindle, revolves and thus the maximum straightness and concentricity are assured. The feed is so arranged that it does not depend on the operator's sense of feel and the smallest drills may be safely used.

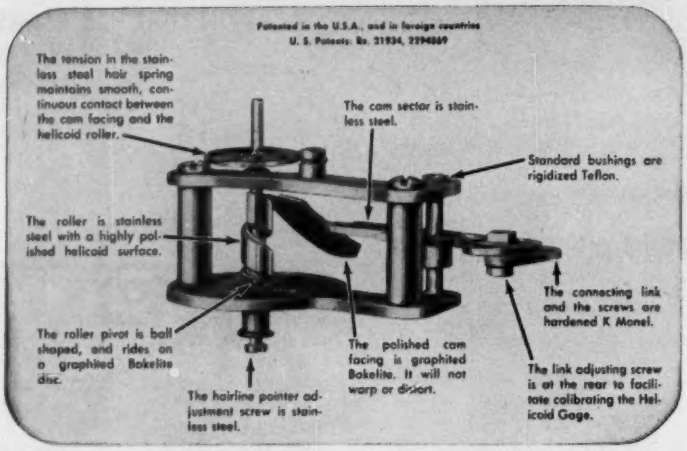


* Smallest commercial drill available.

For full details of Drilling Machine and Instrument Lathes send for catalog T.

Louis Levin & Son, Inc., 3573 Hayden Ave., Culver City, Calif.

CIRCLE 142 ON READER-SERVICE CARD


Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2794689
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides... *Sustained Accuracy... on the toughest jobs*

• Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details

Ask for Catalog DH-65

HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.

929-B Connecticut Ave., Bridgeport 2, Conn.

ACCO

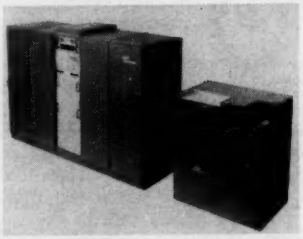
CIRCLE 113 ON READER-SERVICE CARD

INCREMENTAL ENCORDER

New Incremental Encoder, Incrosyn Model IMI 15-210, produces 1024 pulses in single turn with accuracy of ±½ bit. Can be used as bi-directional device by feeding into up-down counter. Zero reference capability of one or more points can be included as well as self-contained interrogation signal. Magnetic pickoff technique allows for slewing rates of up to 3000 rpm with 100-kc carrier.—*Data Tech, 238 Main St., Cambridge 42, Mass.*

CIRCLE 266 ON READER-SERVICE CARD

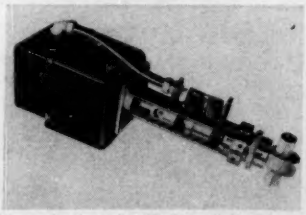
CIRCUIT TESTER



New FACT-RC random access, card-programmed Automatic Circuit Tester checks wiring hardnesses and electrical assemblies for current continuity and high potential. Tests require 1 card/circuit; computer processes 72 cards/min. Faults noted by type and location on print-out tape, and by cards as they fall into "condition of circuit" bins.—*Hughes Aircraft Co., El Segundo Div., Box 90426, Airport Sta., Los Angeles 45, Calif.*

CIRCLE 267 ON READER-SERVICE CARD

ELECTRONIC VALVE ACTUATOR



New electronic Valve Actuator operates off standard 115-v power and can be mounted on any type of reciprocating or rotary stem valve. Contains electronic balancing relay assembly which accepts any type of a-c or d-c control signal. Relay assembly produces electrical corrective demand signal. Output torque is from 25 to 150 ft-lb.—*Electro-Mech Corp., Reliance Instrument Div., 500 Livingston St., Norwood, N. J.*

CIRCLE 268 ON READER-SERVICE CARD

A. D. JONES OPTICAL WORKS

2400 MASSACHUSETTS AVENUE
CAMBRIDGE 40 MASSACHUSETTS
TRowbridge 6-3368—3369

People usually associate Optics with glass only. The following materials, successfully processed here by sawing, grinding and polishing or drilling are of value to designers, engineers and manufacturers. Most materials are supplied by our customers for their orders.

ALUMINA
ALUMINUM
ARSENIC TRISULPHIDE
BARIUM TITANATE
BRASS
CALCIUM TUNGSTATE
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
CORNING 707
CORNING 7052
FERRITE
FERROX
FLUORIDE, CALCIUM
FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM FERRITE
MAGNESIUM STANIDE
NICKEL OXIDE
NIOBIUM
PLATINUM
POTASSIUM BROMIDE
PYREX
QUARTZ, CRYSTAL
QUARTZ, FUSED
SAPPHIRE
SILICON
SODIUM CHLORIDE
STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
VYCOR
X-RAY LEAD GLASS
VANADIUM

CIRCLE 61 ON READER-SERVICE CARD

CHECK BOTH

OXYGEN in the feedwater | **HYDROGEN** in the steam

OXYGEN is well known to be an active source of boiler corrosion. The oxygen dissolved in feedwater is determined directly and continuously recorded upon the Cambridge Dissolved Oxygen Recorder.

The oxygen set free by dissociation of the water in the boiler is equally damaging. Its presence is determined by measuring the free hydrogen in the steam condensate. Cambridge Analyzer-Recorders provide continuous records of both the oxygen dissolved in the feedwater and the hydrogen in the steam—on one chart if desired, thus enabling prompt corrective measures to be taken.

Complimentary copies of these bulletins will be sent upon request.

A. S. T. M. BULLETIN D1588-58T
CAMBRIDGE BULLETIN NO. 148 BP

Instrument shown may be used to record either O_2 or H_2 or both simultaneously. Cambridge also makes Hydrazine Analyzers, PH Recorders and instruments for analyzing gaseous mixtures.

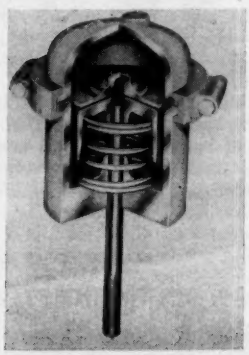
CAMBRIDGE INSTRUMENT CO., INC.
1661 Graybar Bldg., 420 Lex. Ave., N.Y. 17, N.Y.

CAMBRIDGE
Dissolved O_2 & H_2
ANALYZERS

Pioneer Manufacturers of Precision Instruments

CIRCLE 62 ON READER-SERVICE CARD

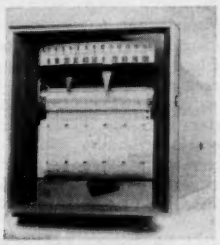
ROLLING DIAPHRAGM ACTUATORS



New Rollomotor air-operated, rolling diaphragm actuators for sliding stem operation of valves, rheostats, speed reducers, etc. are available in air-to-close, spring-to-open (normally open), air-to-open, trapped-air-to close (normally closed), air-to-close with positioner (normally open), and air-to-open with positioner (normally closed). Piston does not touch cylinder wall, allows strokes up to 12", high operating pressures, and use of pistons of smaller diameter than are normally used.—*RKL Controls, Inc., Hainesport, N. J.*

CIRCLE 269 ON READER-SERVICE CARD

MINI PNEUMATIC INSTRUMENTS



New PneumatiK Tel-O-Set line consists of 12 major types of 4" indicating, recording and controlling devices which enable manual-automatic control transfer without matching pressures. Instruments include 1- and 2-pen strip chart recorders without and with control, single and two-station recording cascade control, 1- and 2-point indicators with and without control, proportional plus reset controller and proportional plus reset plus rate controller. All operate over 3 to 15 psi, combine with any compatible transmitter and final control element. Specs. 1004-1, 2, 3.—*Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Phila. 44, Pa.*

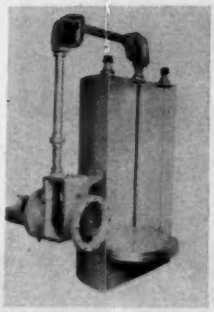
CIRCLE 270 ON READER-SERVICE CARD

AC LINE DRIVER

New EECO-863 AC Line Driver, 12-channel buffer amplifier for use with a-c signals from 100 to 20,000 cps, distributes locally generated amplitude modulated time code signal over land line distribution system to remote instrumentation sites. Unit accepts signals generated by time code generators including EECO 801, 802, 803, 804, 811, 812, and others.—*Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 271 ON READER-SERVICE CARD

TANK GAGE



New float-operated Dir-O-Gage is supplied with all components and hardware for installation on bolted or welded tanks up to 24' high. Features large dials calibrated in feet, inches and ⅛ inches; Neg'ator Motor rewind, no counter-weight; up to 8 individually adjustable electric-alarm, explosion-proof switches.—*Instruments, Inc., Sub. National Tank Co., Box 556, Tulsa, Okla.*

CIRCLE 272 ON READER-SERVICE CARD

AC-DC INSTRUMENT CALIBRATION

to 0.25% Accuracy

Model 829A provides a single package method of maintaining plant-wide instrument accuracy at modest cost.

Full-scale calibration accuracy of 0.25% for both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes is provided by this completely self-contained unit. AC calibrations can be performed from 50 to 400 cps., depending on line frequency used, or the Model 829A can be driven by an optional variable frequency power supply (see below).

The Model 829A is a comparison type calibrator, using horizontally mounted standard meters of high accuracy and dependability. Range switches and high voltage discharge circuits are safety interlocked, protecting the standard meters and the meter being tested from accidental overloading. Model 829A can be used effectively and safely by personnel not previously acquainted with instrument calibration techniques. Net price $3,150.

The most compact calibration system available is also mobile.

Photo inset shows the Model 829A secured with shock mounts on the RFL Model 10 Test Equipment Cart with the standard meters recessed into a drop-leaf work shelf. In the Cart is a Model 500 Variable Frequency Power Supply for line regulation and for supplying any frequency for calibration from 50 to 400 cps.

Performance is rigidly guaranteed. Prices are f.o.b. Boonton, N.J. and subject to change without notice.

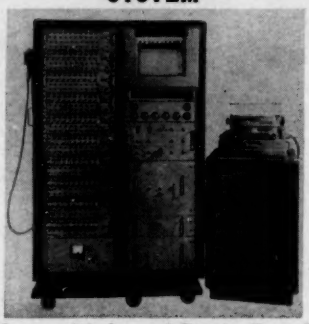
SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

CIRCLE 115 ON READER-SERVICE CARD

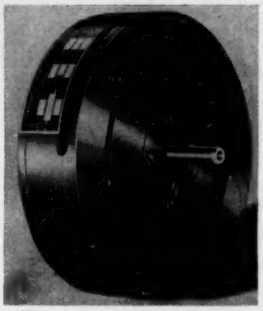
STRAIN GAGE PLOTTING SYSTEM



New multi-channel Strain Gage Recording and Plotting System with digital output utilizes 10 input conditioning modules of 10 channels each. Permanent analog record is produced by recorder. Output is both typewritten log sheet and punched paper tape for computer entry. Bulletin 410.—*B & F Instruments, Inc., 3644 N. Lawrence St., Phila. 40, Pa.*

CIRCLE 273 ON READER-SERVICE CARD

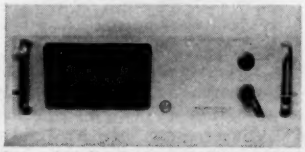
MEMORY DRUM MOTOR



New Hyspersyn electric motors for handling memory drums are synchronous and offer excellent damping. Large loads are synchronized with fast acceleration followed by vigorous pull-in torque. Full load efficiency at 80% assures cool operation. Constance of angular velocity is less than one-part-in-a-million drift over five days working time.—*Bekey Electric Div., Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.*

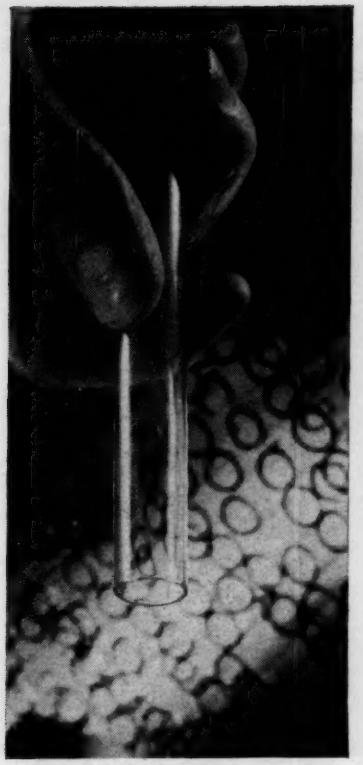
CIRCLE 274 ON READER-SERVICE CARD

LOW-COST OHMMETER



New NLS 784 precision Digital Ohmmeter with printout connection is fully automatic, with automatic range changing, positioning of decimal point, and built-in controls for automatic operation of data printers. Measures at average of 1 reading/sec and with accuracy of ±0.05% of reading plus 1 digit.—*Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.*

CIRCLE 275 ON READER-SERVICE CARD



THIS TUBING CAN SAVE YOU MONEY

This special CORNING® flint glass tubing and rod give you ease of forming, strength, and topflight transparency. They are priced up to 50% lower than PYREX® tubing and rod. They are available immediately.

We developed CORNING brand 0088 flint glass just for the making of low-temperature-service tubing and rod. In uses near room temperature, it resists chemicals almost as well as PYREX brand glasses.

A statistical profile: coefficient of expansion, 92 x 10^{-7}; softening point, 700°C.; annealing point, 521°C.; strain point, 480°C.

We put this glass into apparatus tubing with outer diameters which range from 3 to 51 mm, in capillary and barometer tubing with inner diameters from 0.5 to 4 mm, and in rod with diameters from 3 to 12 mm. All are furnished in 48-inch lengths.

You can get any type in any quantity, quickly. For information on our entire tubing and rod line, write for Bulletin TBG-88.

CORNING GLASS WORKS
10010 Crystal St., Corning, N. Y.
CORNING MEANS RESEARCH IN GLASS

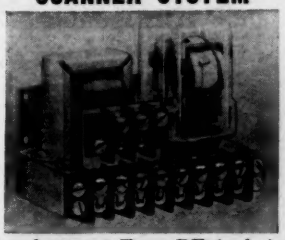
CIRCLE 128 ON READER-SERVICE CARD

CRT PROGRAMMING SWITCH

New 5-pole, 12-position, 5-rps Time Sharing and Programming Switch Model 500736 has four poles which control plus and minus voltages on "X" and "Y" axes of cathode ray tube; fifth pole provides necessary blanking operation between data points. Based on CRT indicator range parameters, switch can handle signal levels of: 10-50 mv, 50-100 mv, 100-mv-1 v, 0-50 v, 0-150 v.—*Instrument Development Labs., Inc., 67 Mechanic St., Attleboro, Mass.*

CIRCLE 276 ON READER-SERVICE CARD

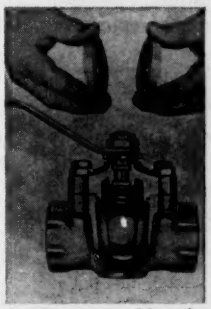
SCANNER SYSTEM



New low-cost Type PE-1 photoelectric scanner system provides positive response when light-beam is interrupted by objects as small as ¼" wide at counting rates up to 500/min. Operating ranges can be up to 8'. Uses power-type photocell with high infrared sensitivity; requires no tubes or transistors.—*Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.*

CIRCLE 277 ON READER-SERVICE CARD

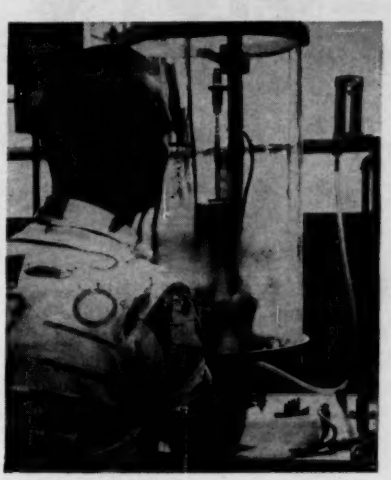
1000°F BALL VALVE



New McCannaseal-models Ball Valves having Graphitar seats permit use to 1000°F with 316 s-s bodies, ASA-rated 300-lb, suitable for pressures up to 355 psig; carbon steel for pressures to 80 psig. Same materials with 150-lb ASA rating are suitable for pressures to 40 psig. Spring forces ball downward into wedge-seat arrangement resulting in leaktight closure.—*Hills-McCanna Co., 400 Maple Ave., Carpentersville, Ill.*

CIRCLE 278 ON READER-SERVICE CARD

Varian protects hydrogen brazing operations with J-W gas detector



Construction of Varian Associates backward wave oscillator tube involves brazing two copper tubes with silver eutectic. In the operation shown an oxygen flame in a hydrogen atmosphere flows the eutectic.

Varian protects against a build-up of an explosive gas mixture in the shop with a J-W warning system. The indicating unit (model RV, shown at right) is situated in a central place and monitors nine work stations automatically at four minute intervals.

Varian's explosive gas detector system was designed to custom requirements. If you have an explosive gas hazard in your operations, contact Johnson-Williams for information on standard models and J-W engineering service on gas warning systems.

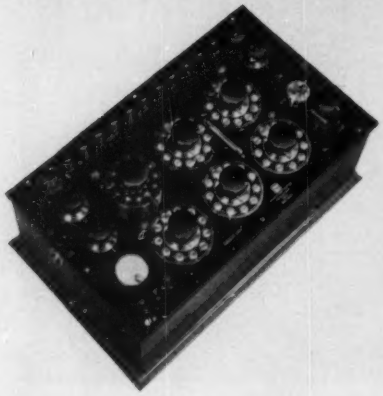
J-W **Johnson-Williams, Inc.**
Palo Alto 13, California

Leadership in explosion prevention since 1927

Canadian customers please write:
Safety Supply Co., Toronto, Ont.
Fleck Bros. Ltd., Vancouver, B. C.

CIRCLE 141 ON READER-SERVICE CARD

Measure to within ±0.01 C from −190 to +500C



with L&N's Type G-2 Mueller Bridge

When used with the L&N 8163 Platinum Resistance Thermometer, this Type G-2 Mueller Bridge provides a standard of temperature throughout the range of −190 to +500 C with an accuracy in ohms equivalent to ±0.01 C.

Invaluable in the advanced research laboratory, the G-2 facilitates the making of a variety of highly accurate temperature measurements . . . of specific heats; of boiling and freezing points of many chemicals; and in calorimetry, for the precise determination of heats of combustion of coals, gases, oils, etc.

LIST NO.—8069-B TYPE G-2 MUELLER BRIDGE, *normally available for immediate delivery.*

Measuring Arm—0 to 111.111 ohms in steps of 0.0001 ohm.

Constant Temperature Chamber — With thermostatically controlled heater; holds resistors of measuring circuit constant within ±0.01 C at about 35 C.

Ratio Arms—1,000 ohms each. Adjustable to equality.

Milliammeter—Range 0 to 5 ma. Indicates current in the resistance thermometer.

Limit of Error—Within a few ten thousandths of an ohm or a few parts in a hundred thousand, whichever is larger, provided bridge and resistance thermometers are calibrated in terms of same resistance unit at six-month intervals.

Case—Polished mahogany with cover; 9¼" (h) x 21¼" (w) x 13" (d).

Price: $4300.00 f.o.b. Phila. or North Wales, Pa. (subject to change without notice). Specify List No. 8069-B when ordering from L&N, 4955 Stenton Ave., Phila. 44, Pa. or nearest L&N office.

LEEDS [N] NORTHRUP
Instruments Automatic Controls • Furnaces

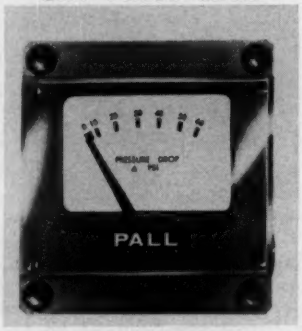
CIRCLE 117 ON READER-SERVICE CARD

CUSTOM MEMORY SYSTEM

New custom memory System, built around a Bryant Model 10024 Memory drum for installation by U.S. Post Office Department for experimental coding and sorting of mail, consists of three sections: central logic section; complex input and output devices; and storage and memory access section. Capacity is 1,250,000 bits of information, access time less than 17 msec. Drum is equipped with 512 magnetic heads, divided into eight groups for eight-bit parallel operation.—*Bryant Computer Products, Div. Ex-Cell-O Corp., 852 Ladd Rd., Walled Lake, Mich.*

CIRCLE 279 ON READER-SERVICE CARD

DIFF PRESS GAGE



New Differential-Pressure Gage with 60-psi scale and 3000-psi working pressure rating has accuracy of ±2%, temperature range of −40° to +200°F. No mechanical linkages; operates by magnetic coupling which eliminates possibility of leakage.—*Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y.*

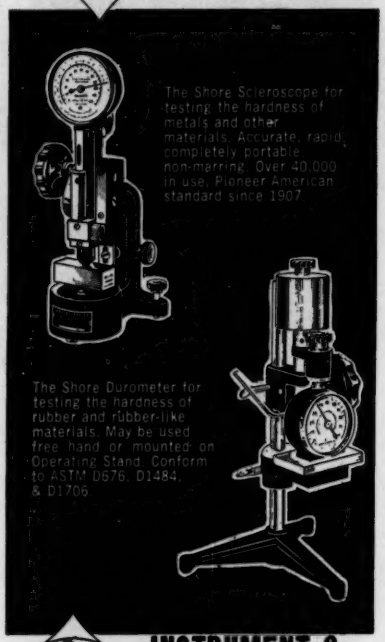
CIRCLE 280 ON READER-SERVICE CARD

ROTARY ELECTRIC ACTUATOR

New Rotary Electric Actuator for use on Type "B" Lo-torq Valves up to 1" size with no modification has direct drive through precision planetary gear train. Operating time is ¾ sec for 45°, and 1½ sec for 90° movement.—*Republic Mfg. Co., 15655 Brookpark Rd., Cleveland 35, Ohio.*

CIRCLE 281 ON READER-SERVICE CARD

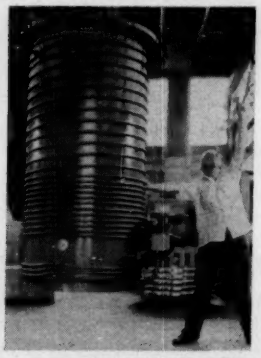
Shore HARDNESS TESTING


The Shore Scleroscope for testing the hardness of metals and other materials. Accurate, rapid, completely portable, non-marring. Over 40,000 in use. Pioneer American standard since 1907.
The Shore Durometer for testing the hardness of rubber and rubber-like materials. May be used free hand or mounted on Operating Stand. Conform to ASTM D676, D1484, & D1706

Shore INSTRUMENT & MFG. CO., INC.
90-35 VAN WYCK EXPRESSWAY
JAMAICA 35, N.Y., U.S.A.

CIRCLE 118 ON READER-SERVICE CARD

GIANT VACUUM PUMP



New Type PMC-50000 32"-dia oil-diffusion Vacuum Pump was developed specifically for fast, clean evacuation of space chambers used in space simulation studies. Provides plateau speed of 52,000 lit/sec throughout 3×10^{-5} to 4×10^{-4} mm Hg pressure range. Baffled ultimate pressure is 2×10^{-6} mm Hg and backstreaming rate is 0.194 mg/cm²/hr.—*Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.*

CIRCLE 282 ON READER-SERVICE CARD

For More Information Circle Appropriate Number on Readers Service Card

COMPLEX-PROGRAMMING TIMER

New Timer for intricate programming combines 115-v ac 400-cycle synchronous motor with 28-v dc magnetic clutch to provide two or more fixed or adjustable timing sequences with automatic reset upon completion. Withstands 15-G shock, sealed against environment. Repeatability of adjustable time delay is ±3% of maximum setting. Rating is 4 amp resistive at 28 v dc.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton 4, Ohio.*

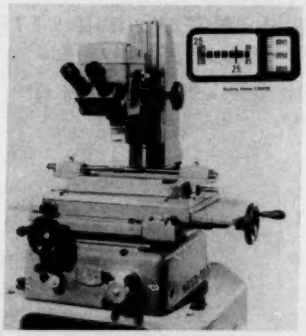
CIRCLE 283 ON READER-SERVICE CARD

WIDEBAND AMPLIFIER

New Wideband Amplifier Model WB-100 with bandwidth of 1 to 100 Mc min maintains flatness within ±1 db, has nominal 50-ohm input and output impedance, low noise.—*Teltronics*, 23-27 *Main St., Nashua, N. H.*

CIRCLE 284 ON READER-SERVICE CARD

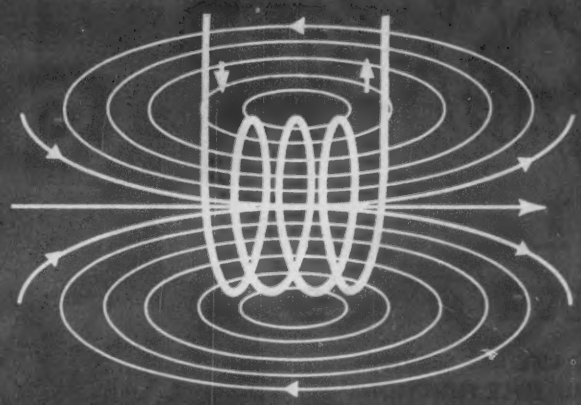
TOOLMAKER MICROSCOPE



New Toolmaker Microscope combines increased range of 3" x 8", purely optical measuring stage, and binocular microscope tube. Scales are read directly in 0.0001" through single projection window (see insert in illustration). Binocular intermediate image tube has 1:1 relay system plus second relay of 5:1. With the same optics, two series of magnifications become available: 10x, 20x and 30x; 50x, 100x and 150x.—*Opto-Metric Tools, Inc.*, 137 *Varick St., New York 13, N. Y.*

CIRCLE 285 ON READER-SERVICE CARD

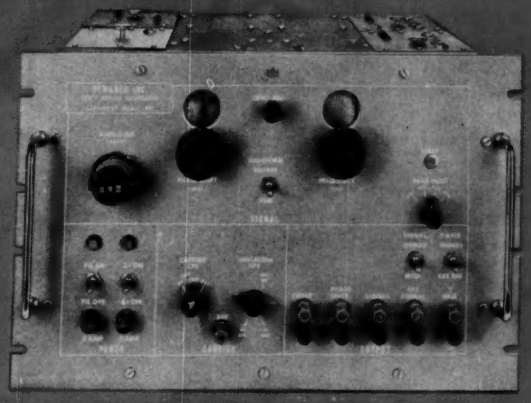
FOR ACCURATE* CHECK OUT OF SERVO SYSTEMS...



REMANCO

SERVODYNE†

SERVO ANALYZER



*So Accurate, Servodyne exceeds its own tight specifications

Repeatability . . . Servodyne excels. It's all electronic — no mechanical devices. Rugged — and simple to maintain.

Wherever servo-mechanisms are used — in flight control, flight table, automated machinery, and other servo applications — Remanco's Servodyne Servo Analyzer provides a reliable means for system checkout. In practice, accuracy exceeds rigid factory standards prescribed for the unit. Featuring modular design for easy maintenance, the Servo Analyzer is rugged, simple to operate . . . For complete test and evaluation of AC servo systems . . . For frequency phase, and transient response tests of DC servos. Frequency ranges from .001 to 100 cps; sine or square wave outputs, entire range. Other servo analyzers designed and built to customers' specifications are available.

† Trade Mark

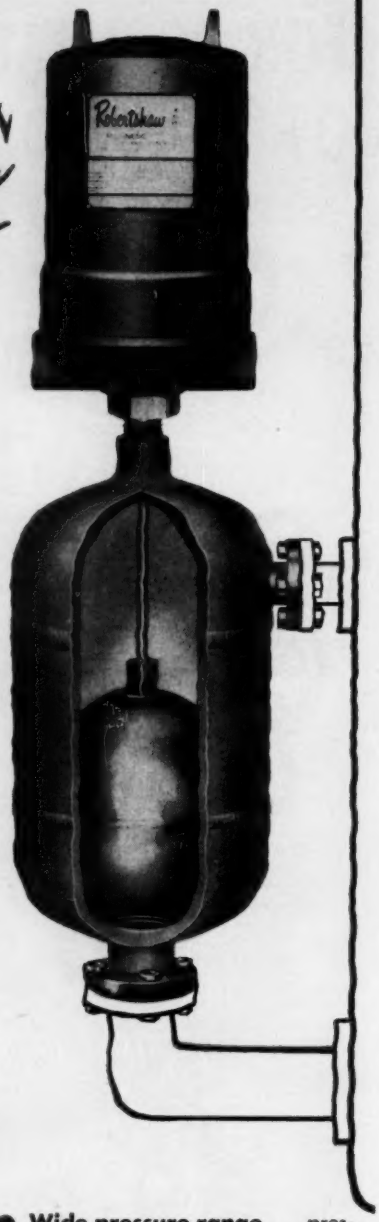
REMANCO INCORPORATED

1805 COLORADO / SANTA MONICA, CALIFORNIA

CIRCLE 119 ON READER-SERVICE CARD

NEW CERAMIC MAGNET Level Switches

FOR LIFETIME SERVICE . . .
MULTIPLE FUNCTIONS



Start pumps, open or shut valves, sound alarms automatically . . . with these new high-load "Level-Ac" liquid level controls by Robertshaw, actuated by ceramic permanent magnets.

Designed for open or pressurized systems, these float-type switches provide constant control of levels in boilers, process vessels or other containers, with a long list of major advantages:

- **Extreme resistance to demagnetization** . . . highest of any commercial magnetic material.
- **Multiple switching functions** (up to 7 combinations) in small housing due to higher concentration of magnetic force.
- **Pneumatic or electric models** . . . explosion-proof housing available for electric switches.
- **Choice of mountings** . . . all-welded or flanged external float cages; top-mounting with tubular or 3-rod guides; side-mounting.
- **Wide pressure range** . . . pressure-equalizing floats for high-pressure applications.
- **Fewer moving parts** for trouble-free operation, lower cost.
- **"High-load" snap switch** . . . avoids need for leveling.

Just out! Complete description in new folder RL-765

Robertshaw

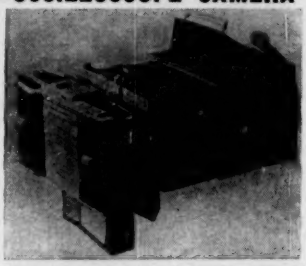
Robertshaw-Fulton Controls Company

MR. CONTROLS

FULTON SYLPHON DIVISION • KNOXVILLE 1, TENNESSEE

CIRCLE 120 ON READER-SERVICE CARD

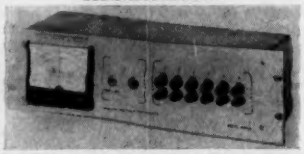
OSCILLOSCOPE CAMERA



New Camera System for oscilloscope photography, Mark II Oscillotron, has unique design feature which permits operator to select any object-to-image ratio from 1:1 through 1:0.5 infinitely without extra lenses or other parts. As many as 13 multiple exposures can be made on one film. Equipped with either Polaroid roll film back or 4x5 cut film back.—*Beattie-Coleman, Inc., 1012 N. Olive St., Anaheim, Calif.*

CIRCLE 286 ON READER-SERVICE CARD

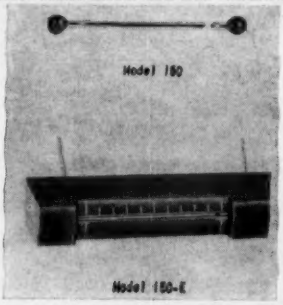
PRIMARY VOLTAGE REFERENCE



New Model PVR-6 solid-state Primary Voltage Reference has guaranteed stability of 2 ppm/3 months and 3 ppm/year, calibration accuracy of 0.0015%. Tests prove stability of new reference may be equal to or better than stability of saturated cell (temperature controlled).—*Calibration Standards Corp., 1025 Westminster Ave., Alhambra, Calif.*

CIRCLE 287 ON READER-SERVICE CARD

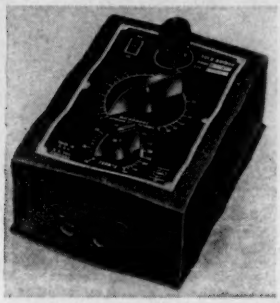
MINI AMPERE-HOUR METER



New miniature Ampere-hour Meter Model 150 is direct reading microcoulometer, principle of operation based on Faraday's Law for electrochemical deposition. Consists of drawn capillary glass tube containing mercury anode separated from mercury cathode by liquid electrolyte gap; under applied voltage, current flow transfers mercury quantitatively across electrolyte, giving linear displacement of gap down length of tube.—*Curtis Instruments, Inc., 45 Kisco Ave., Mount Kisco, N. Y.*

CIRCLE 288 ON READER-SERVICE CARD

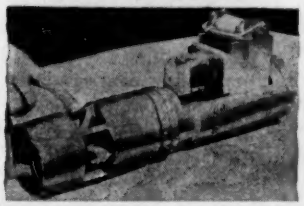
SOLU BRIDGE FOR HYDROFLUORIC ACID



New Solu Bridge Model RD-57C has true a-c Wheatstone bridge circuit incorporating electron eye tube as null indicator. Employing manual temperature compensator covering 0-35°C, it uses cell with constant of 10.0. Readings are independent of line voltage variations and tube characteristics. Wired to alarm bell and electrically operated valve, controlling instrument can measure, signal, and stop liquid flow when electrolyte content exceeds control setting.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.*

CIRCLE 289 ON READER-SERVICE CARD

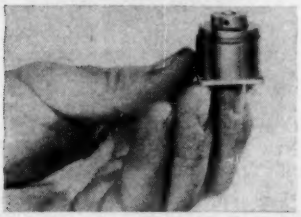
HI-SPEED VALVE



New high-speed Valve for aircraft arresting device uses explosive air blast to open 3"-dia valve orifice (closed by poppet held in place by double toggle assembly that is tripped by solenoid). Valve seal is broken 9 msec after solenoid plunger starts moving, port is wide open 6 msec later. Max operating pressure is 1500 psi.—*Research, Inc., Box 6164, Minneapolis 24, Minn.*

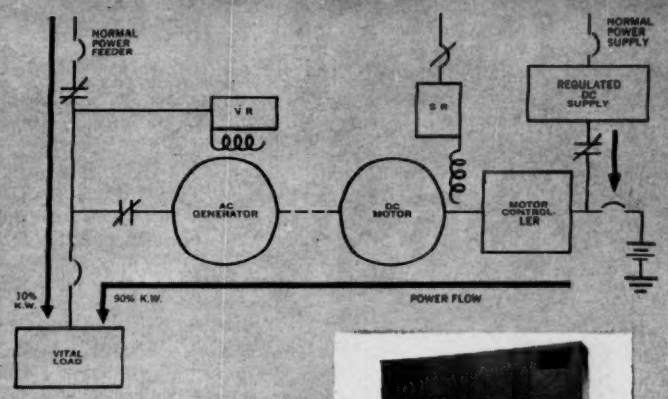
CIRCLE 290 ON READER-SERVICE CARD

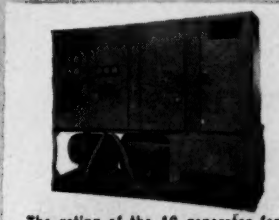
MINI CLUTCHES



Fast-acting miniature Clutches ranging in size from less than 1" dia to 4" dia and in torque ratings of 1.5 to 240 in lb use electromagnetic operating principle which permits stepless torque modulation and operation from variety of actuating devices.—*Warner Electric Brake & Clutch Co., Beloit, Wis.*

CIRCLE 291 ON READER-SERVICE CARD





The rating of the AC generator for this Kearfott system is 40 KW, 3 phase, 60 cycle, 460 volts.

CONTINUOUS UNVARYING POWER FOR VITAL INSTRUMENTATION IN CHEMICAL PROCESSING

A TYPICAL APPLICATION OF KEARFOTT UNINTERRUPTED POWER SYSTEMS

In chemical processes where even a split-second interruption of computers and related instruments can cause heavy losses, protection against power failure pays high dividends on a relatively modest investment. Take, for example, the Kearfott system pictured here, which assures surge-free entrance of emergency power in zero time in case the normal input varies or fails.

In normal operation, the DC motor runs continuously on power from the static supply, which also keeps the batteries fully charged at all times. The AC generator operates in parallel with the main power and furnishes about 90% of the vital load requirement.

If the main power fails, the DC motor continues to run, drawing its current from the batteries. Simultaneously, the AC generator assumes 100% of the vital load. When main power is restored, the system automatically reverts to normal operation.

Kearfott systems are available with generator ratings to 150 KVA 60 and 400 cycles, single and polyphase, and provide frequency, voltage and transfer regulation as required by the application.

Write for complete data

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE 121 ON READER-SERVICE CARD

NEW

Stromberg-Carlson® lightweight telephone handsets

. . . for a wide range of applications such as dictating systems, mobile radio, carrier and microwave.

These new lightweight Stromberg-Carlson handsets, No. 33 and No. 35, incorporate push-to-talk switches, broadening the range of their applications. Both feature high-gain, high-efficiency transmitter and receiver.

The No. 33 model is furnished with a bar-type switch, located on the underside of the handle.

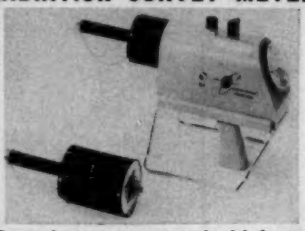
The No. 35 handset is furnished with a button switch on the side of the handle near the receiver end. Also available with both button and bar switches.

For technical details and ordering information, contact any of these sales offices: Atlanta—750 Ponce de Leon Place, N.E.; Chicago—564 W. Adams Street; Kansas City (Mo.)—2017 Grand Avenue; Rochester—1040 University Ave.; San Francisco—1805 Rollins Rd.

GENERAL DYNAMICS /ELECTRONICS

CIRCLE 122 ON READER-SERVICE CARD

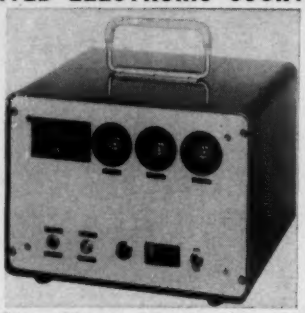
RADIATION SURVEY METER



New battery-operated high-range Model 2586-T Cutie Pie Survey Meter for rate of dose and accumulative dose radiation measurements features two interchangeable ionization chambers. Rate of dose chamber has ranges of 0.2.5, 0-25, and 0.250 roentgens/hr. Accumulated dose chamber has ranges of 0-0.25, 0-2.5, and 0-25 roentgens.—*Nuclear-Chicago Corp., 359 E. Howard Ave. at Nuclear Dr., Des Plaines, Ill.*

CIRCLE 292 ON READER-SERVICE CARD

GATED ELECTRONIC COUNTER



New Electronic Counter Series 181709 for liquid measuring systems starts counting when gate is open, stops when it is closed. Counts at speeds up to 300,000 counts/min, operates in temperature range of +130° to −30°F. Unit is nine-decade counter consisting of three electronic decade counter tubes and 6-digit high-speed magnetic counter.—*Veeder-Root, Inc., Electronic Controls Div., 5 Maple St., Danvers, Mass.*

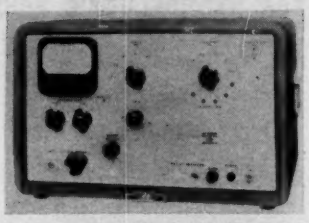
CIRCLE 293 ON READER-SERVICE CARD

SOLID-STATE VOLTMETER

New solid-state Digital Voltmeter Series 5001 "features 10 times higher accuracy and resolution than any other solid state digital voltmeter at the low end of normal digital voltmeter ranges." Automatic range and polarity selection are provided on ranges of ±1.1999, ±11.999, ±119.99 and ±1199.9 v. Average of 200 readings/sec is achieved (not including sign or range change) with maximum error of ±0.01% of full scale ±1 digit.—*Electronic Associates, Inc., Long Branch, N. J.*

CIRCLE 294 ON READER-SERVICE CARD

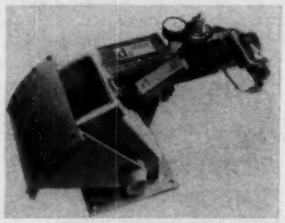
VLF RECEIVER



New transistorized Model DY-5842 VLF Receiver permits accurate calibration of local frequency standards by comparison with station-WWVL broadcasts. Features include 1-μv sensitivity, five crystal-controlled channels between 14 and 60 kc, a carrier level meter, and recorder output.—*Dymec Div., Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.*

CIRCLE 112 ON READER-SERVICE CARD

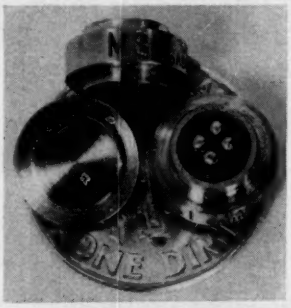
SWING GATE FEEDER



New Swing-Gate Feeder for free flowing materials controls flow into automatic weighing systems or continuous process streams. Available with either two-position on-off control or with modulated feed control to obtain full-flow to cut-off with modulated response.—*Dynametrics Corp., Northwest Industrial Park, Burlington, Mass.*

CIRCLE 116 ON READER-SERVICE CARD

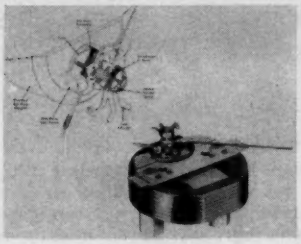
PRESSURE TRANSDUCER



New ¼"-dia Type PO3BA5 Pressure Transducer measures in 0-50 psia to 0-500 psia range; uses semiconductor strain sensing elements arranged in full Wheatstone bridge to convert pressure-induced strains into high level output signals; often eliminates use of amplifiers, improving reliability and reducing system cost and maintenance; natural frequency 40 kc for 100-psia range—*Micro Systems, Inc., 319 Agostino Rd., San Gabriel, Calif.*

CIRCLE 295 ON READER-SERVICE CARD

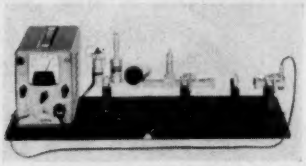
SUSPENSION TYPE METER



New suspension-type ultra-sensitive Panel Meter uses short, very thin, narrow band kept tightly suspended on special spring terminals to support coil and its moving counter parts. No pivots, jewels, hairsprings, or rolling friction. Special conical shaped spring anchors provide maximum resiliency for taut suspension wire in case of shock or jar.—*Triplett Electric Instrument Co., Bluffton, Ohio.*

CIRCLE 296 ON READER-SERVICE CARD

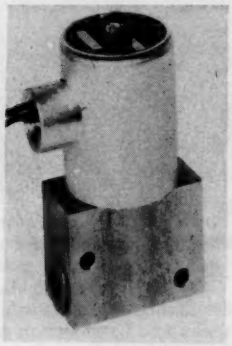
MICROWAVE DEMONSTRATOR



New low-cost Ed-Set portable demonstration unit simplifies study of energy radiation at speed of light, allows radar signals to be sent 30′, and interference patterns to be plotted and calculated. It includes power supply, amplifier, tube mount, frequency meter, attenuator, slotter line, crystal detector, accessories, and instruction manual. Ed-Set approximates standards of laboratory precision sufficient to measure speed of light in 9%.—*Budd-Stanley Co., Inc.,* 175 *Eileen Way, Syosset, N. Y.*

CIRCLE 297 ON READER-SERVICE CARD

SOLENOID VALVES

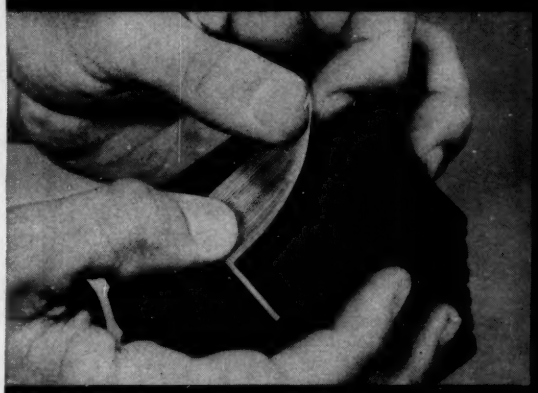


New line of two-way Solenoid Valves for oil pressures to 3000 psig is made as NO or NC pilot-operated poppet types. Features free reverse flow in either energized or de-energized position. Bulletin available—*Fluid Power Accessories, Inc., Box* 64, *Glenview, Ill.*

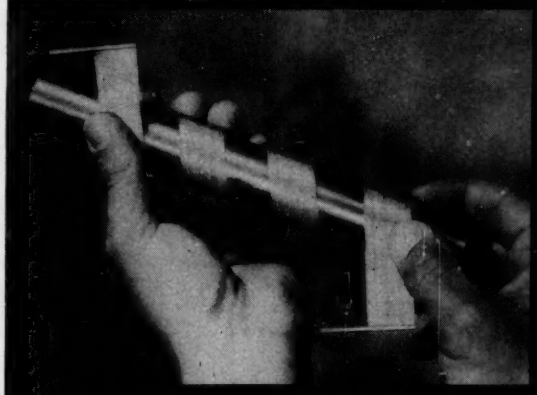
CIRCLE 298 ON READER-SERVICE CARD

CIRCLE 124 ON READER-SERVICE CARD——→

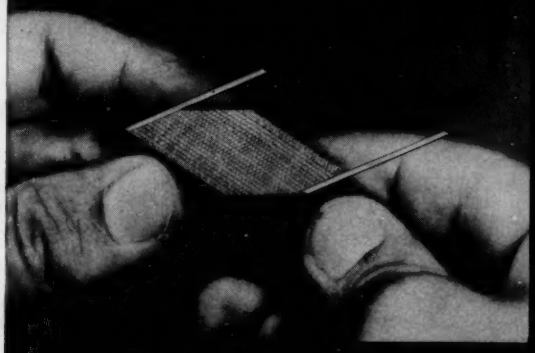
NEW WOVEN TEMPERATURE DETECTOR-GREATER ACCURACY AT LOWER PRICE!



Just peel off and stick on.



Form to fit curved surfaces.



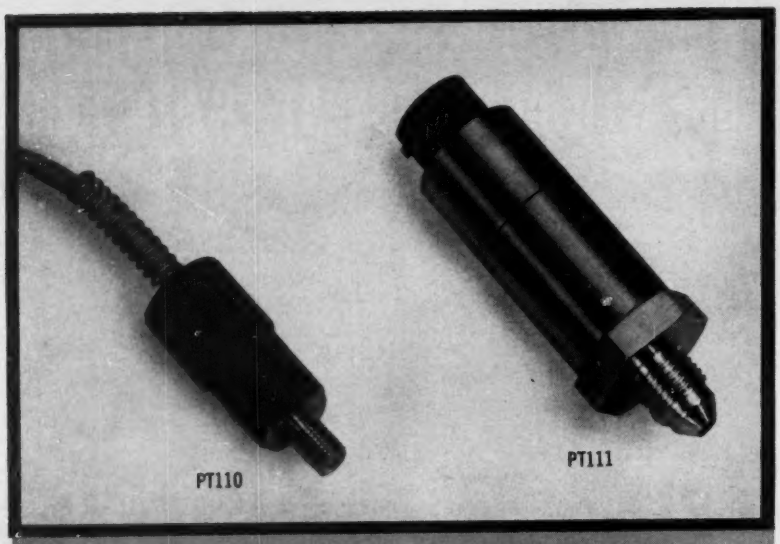
Complete accuracy on irregular areas.

The new CIC Temperature Detector combines ruggedness and increased temperature ranges (up to 1000 degrees Fahrenheit) to give you a whole new parameter in the measurement of temperature by resistance change. Its unique design of nickel or platinum resistance wire woven through fiber glass carrying threads assures sharp and accurate response — higher resistance per linear inch — calibration within ½% — and complete freedom from strain gauge effect.

Best of all the price is one third to one half that of ordinary Temperature Detectors. **You have to see it to believe it!** Just drop us a line for complete information. Evaluation prototypes immediately available.

CONTROL INDICATING CORPORATION
AN AFFILIATE OF HI-G INC.
BRADLEY FIELD, WINDSOR LOCKS, CONN.

CIC



MINIATURE PRECISION PRESSURE TRANSDUCERS

◇ HIGH ACCURACY ◇ HIGH OVERLOAD ◇ LOW COST

Dynisco's new models PT110 and PT111, bonded strain gage transducers are ideally suited for high pressure applications requiring a miniature high-accuracy device with high overload characteristics yet they are low in cost.

PRESSURE RANGES
MODELS PT110 and PT111

Full Scale Pressure Rating	Maximum Pressure
0-1000 PSIG	4,000 PSIG
0-3000 PSIG	15,000 PSIG
0-5000 PSIG	20,000 PSIG
0-10,000 PSIG	20,000 PSIG

PERFORMANCE SPECIFICATIONS

Combined Non-linearity and Hysteresis*	0.25% F.S.
Repeatability	0.1% F.S.
Temperature Range	−65°F. to +250°F.
Temperature Drift	1% F.S./100°F.
Temperature Effect on Sensitivity	½% F.S./100°F.

*Deviation from a straight line thru the zero pressure and full scale pressure output points.

Dynisco

DYNISCO
DIVISION OF AMERICAN BRAKE SHOE COMPANY
42 CARLETON STREET • CAMBRIDGE 42, MASSACHUSETTS

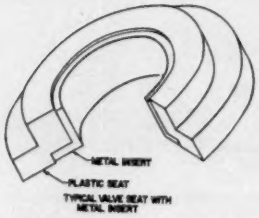
CIRCLE 125 ON READER-SERVICE CARD

ELECTRONIC INTEGRATOR

New Electronic Integrator PX 592 for use with any standard servo-drive recorder is suited for use in gas chromatography. Automatically computes integral of chromatogram and records it in bar graph form using same pen on same strip chart as original recording. Features automatic reset at full-scale integral reading and special relay for hooking up pipping pen to indicate all resets on strip chart.—*Ridgefield Instrument Group, Div. Schlumberger Corp., Ridgefield, Conn.*

CIRCLE 299 ON READER-SERVICE CARD

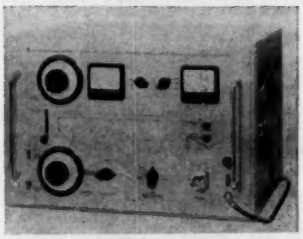
SOFT-SEAT VALVE



New disc-type Plastic Valve Seat with metal insert improves operating characteristics and increases life of new and old valves. Bottom of disc-type plastic valve seat counterbored to receive flanged metal bushing that forms seat orifice. Metal orifice edge withstands much higher fluid velocity without wire drawing or erosion.—*Robbins Aviation, Inc.*, 2350 *E. 38 St., Los Angeles 38, Calif.*

CIRCLE 300 ON READER-SERVICE CARD

UHF POWER GENERATOR



New Power Signal Generator Type SIRD with frequency range of 275 to 3000 mc features 20-w maximum output, calibrated output meter plus 80-db attenuator, direct-reading frequency scale, and band switch without interchangeable cavities. Determines radiation characteristics of aerials, measurements being carried out on filters and four-terminal networks of high attenuation or on wattmeters and directional couplers of high coupling attenuation and directivity.—*Rohde & Schwarz*, 11 *Lexington Ave., Passaic, N. J.*

CIRCLE 301 ON READER-SERVICE CARD

Look to November 1961 issue of Instruments and Control Systems for expert treatment of this important control topic - - -

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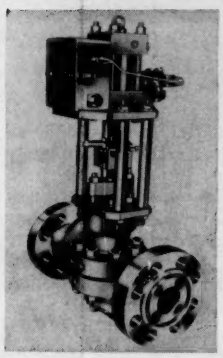
9/61

ELECTROHYDRAULIC ACTUATOR



New custom designed 20,-000-Series, Model EHA-1, Electro-hydraulic Actuator which converts electrical signal from automatic or manual electrical control station to hydraulic force consists of (1) transistorized amplifier with plug-in circuits, (2) conductive plastic infinite-resolution-type feedback potentiometer, (3) hydraulic servovalve, and (4) heavy-duty power cylinder. Features fast speed, high frequency response.—*Annin Co., 1040 S. Vail Ave., Montebello, Calif.*

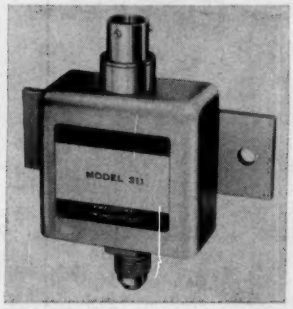
CIRCLE 302 ON READER-SERVICE CARD

CALIBRATION INDICATOR

New portable Type 65 Automatic Null Balance Calibration Indicator is for calibration service with either tension or compression loads and can be used to indicate weight, force and thrust. Two types, 65 and 65A, with system accuracy of ±0.1%.—*Baldwin-Lima-Hamilton Corp., Electronic & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.*

CIRCLE 303 ON READER-SERVICE CARD

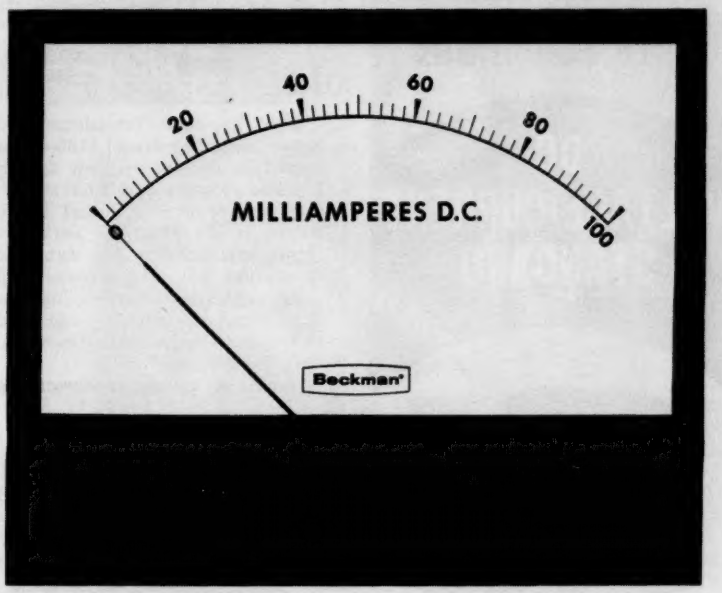
ABSOLUTE PRESS TRANSDUCER



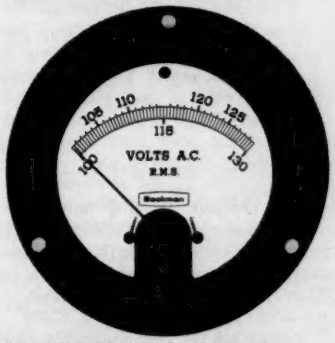
New Absolute Pressure Transducer Model 311 utilizes Ni-Span-C Bourdon tube for low temperature error, matched to precision wirewound potentiometer element. Total error band is ±1%. Specifications in Bulletin 311/F/1.—*Bourns, Inc., Instrument Div., 6135 Magnolia Ave., Riverside, Calif.*

CIRCLE 304 ON READER-SERVICE CARD

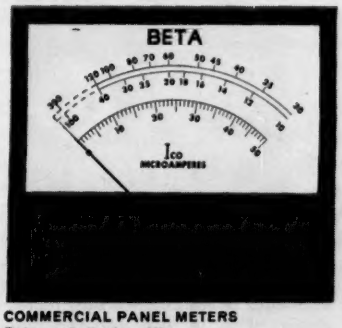
NOW...THE RIGHT ANSWER TO YOUR METER PROBLEM HAS A CLEAN NEW LOOK!



STANDARD PANEL METER
4" x 6" size, 0-100 Milliamps



EXPANDED SCALE AC VOLTMETER
3½" Ruggedized and Sealed



COMMERCIAL PANEL METERS
Beta ray indicator—4½"

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CIRCLE 126 ON READER-SERVICE CARD

ACCURACY
AND RELIABILITY
EVEN UNDER
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VOLTAGE/CURRENT
STANDARD

0.0075% ABSOLUTE ACCURACY
1, 1.0185, 10 VOLT OUTPUTS

0.02% ABSOLUTE ACCURACY
7.5 and 10 MIL OUTPUTS

- ALL SOLID STATE
- ZENER AGING CURRENTS
- INSTRUMENT CALIBRATION
- SYSTEM REFERENCE
- PRODUCTION LINE TEST
- STANDARDS LABORATORY

Based on advanced zener techniques and operational amplifiers, the Rotek Model 401 offers the ultimate in accuracy and stability available in a DC secondary standard. The Rotek DC Standard is designed for Mil Spec environment and may be used under field conditions with accuracy and reliability assured.

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Other Rotek instruments:
AC Voltage Standards
AC/DC Comparators
DC References
System References

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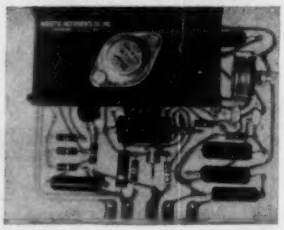
CIRCLE 127 ON READER-SERVICE CARD

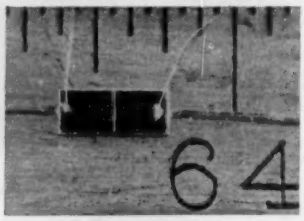
SERVO AMPLIFIER



New low-cost Transistor 400-cps Servo Amplifier Model 1160-4 was designed as companion unit for standard size 11 servo motor having 57/116 volt control phase. Signal input required is less than 0.1 μa/v output. Input impedance is low, can be used in current summing circuits or with input capacitor to provide high impedance input. Mounted on printed-circuit card.—*Magnetic Instruments Co., Inc., Tornwood, N. Y.*

CIRCLE 305 ON READER-SERVICE CARD

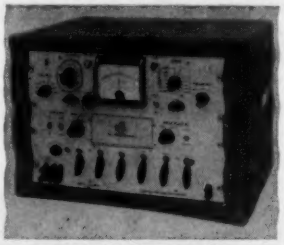
MICRO-PHOTO-SENSOR



New MPS 100 Micro-Photo Sensor designed to provide sensitive light spot displacement measurements is for applications prohibiting mechanical loading and where controlled intensity light spot may be employed. Consists of integral pair of similar silicon photo diodes accurately separated. Output is differential EMF which measures difference in light power incident upon its active cell surfaces.—*Micro Systems, Inc., Subs. Electro-Optical Systems Inc.*, 319 *Agostino Rd., San Gabriel, Calif.*

CIRCLE 306 ON READER-SERVICE CARD

VOLTAGE RATIOMETER



New Model 551 Complex Voltage Ratiometer makes precision a-c measurements in magnitude and phase angle, as well as in-phase and quadrature components. Ratio reference for in-phase measurements is provided by inductive divider (RB-504 Ratio Box), with accuracy of 1 ppm. Null detector is Model VM-204 Three Frequency Phase Angle Voltmeter.—*North Atlantic Industries, Inc., Plainview, N. Y.*

CIRCLE 307 ON READER-SERVICE CARD

PULSE DRIVER CIRCUIT

New Capacity Driver T-165 250-kc Pulse Amplifier features extremely low input impedance, drives up to 75 shift register elements or up to 150 flip-flops at temperatures below +45°C. Some load derating necessary at temps above +45°C. Unit is packaged in standard T-Series container, ⅞" dia x 2 $\frac{3}{16}$" seated height; plugs into standard 9-pin miniature tube socket.—*Engineered Electronics Co., 1441 E. Chestnut Ave., Santa Ana, Calif.*

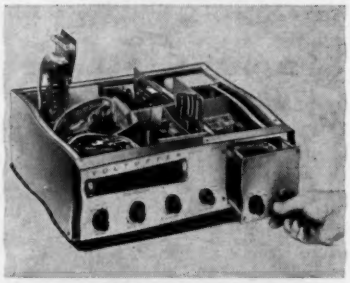
CIRCLE 497 ON READER-SERVICE CARD

VARIABLE-RELUCTANCE PRESSURE TRANSDUCER

New variable-reluctance pressure transducer A40-1 has a "total error band" of ±1%. Total error band concept includes aggregate tolerances within 1%—hysteresis, line voltage, linearity and zero shift; and within 2% under all environmental conditions. Interchangeability is stressed. Over 90% of component parts are common to all ranges, whether absolute or differential transducers. Other characteristics include high power output and low input impedance. A meter movement can be driven directly.—*Astromics, 666 W. Howard St., Glendale 4, Calif.*

CIRCLE 498 ON READER-SERVICE CARD

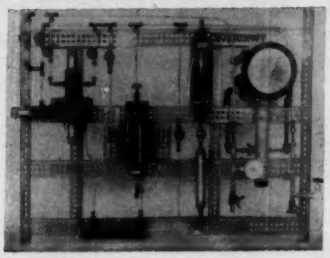
DIGITAL VOLTMETERS/VOLT-RATIO METERS



Six new Series 6000 transistorized *Digital Voltmeters and Volt-Ratio* Meters accept plug-in accessories, allow modification of basic meters, measure voltages from 1 mv to 999.9 v in three ranges within ±0.01% ± one digit. Input impedance is 10,000 megohms at balance on ±9.999 v d-c range. Meters range from low-priced Model 6000 Voltmeter to advanced Model 6500 Volt-Ratio Meter which incorporates automatic range and polarity, dc-ratio functions and ability to drive (without modification) digital data printer.—*Cimron Corp., 1162 Morena Blvd., San Diego 10, Calif.*

CIRCLE 499 ON READER-SERVICE CARD

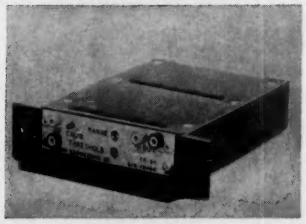
GAS INJECTION DEVICE



New automatic and self-contained device injects gaseous material into larger gas system at constant ratio in parts-per-million range, requires no power source other than that supplied by pressures in main line. Adjustable injection ratio is maintained regardless of pressure, temperature, or flow variations in main stream. Injects radioactive tracers into natural gas lines for flow control.—*Isotopes, Inc., 123 Woodland Ave., Westwood, N. J.*

CIRCLE 308 ON READER-SERVICE CARD

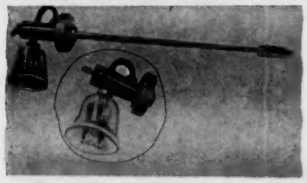
FREQUENCY TO DC CONVERTER



New FR-84 airborne Frequency to DC Converter for use in telemetering flow and tachometer data features solid-state circuitry on printed circuit cards and is qualified for 100-g shock and 20-g vibration. Unit provides 0-5 v d-c output with ±0.25% linearity, overrange limiting at 6.8 v, power consumption of only 45 ma at 2.75 v, sensitivity adjustment and rolloff circuitry to provide inverse-gain-to-frequency circuit for maximum noise rejection. Bulletin 116.—*Waugh Engr., Div., Foxboro Co., 7740 Lemona Ave., Van Nuys, Calif.*

CIRCLE 309 ON READER-SERVICE CARD

THERMOCOUPLE FIXTURE



New non-contact Thermocouple Fixture measures temperatures of objects without touching them. Fine thermocouple filaments are mounted in Bell-shaped housing in which heated film of turbulent air at surface of object is entrapped. Max temp is 1500°F; 15-sec response time for 300°F reading; temp changes of —20°F recorded in 5 sec.—*Instronics Div. Jani Inc., 11238 S. Western Ave., Chicago 43, Ill.*

CIRCLE 310 ON READER-SERVICE CARD

MASSA RECTILINEAR RECORDERS

are selected for exacting applications

CORDIS INTERCALATIVE ANGIOGRAPH

Among the many exacting applications in which Massa Rectilinear Recorders are used is the Cordis Intercalative Angiograph. A two-channel Massa Recorder, Model BSA-250, makes continuous oscillographic electrocardiograms simultaneously with records of signals from transducers monitoring pressures of arteries, veins or from within the heart itself. The event marker, included in the Massa Model BSA-250, records the exact moment when injections and X-rays are made.

The Cordis Intercalative Angiograph injects X-ray opaque fluid into the patient and triggers an X-ray machine during predetermined portions of the heart beat.

While you may not be measuring heart beats your strip-chart recording application may be just as exacting. Massa Division manufactures a complete line of portable and rack mounting direct ink or electric writing Rectilinear Oscillographs ranging from individual 20mm or 40mm pen motors to complete systems with one, two, four, six, eight and twelve channels. D-C and Carrier Preamplifiers are available to permit the recording of practically any phenomenon.

Write for technical bulletin, Model BSA-250.

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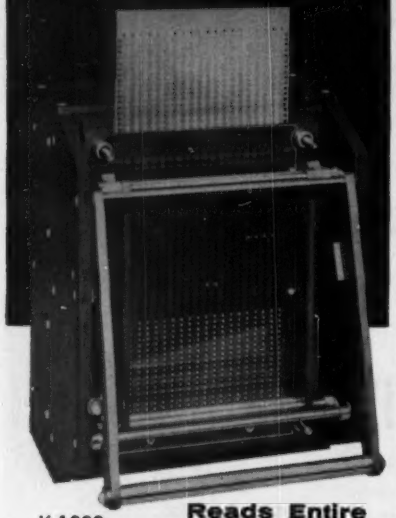
COMPLETE LINE OF MULTI-CHANNEL AND PORTABLE RECORDING SYSTEMS

CIRCLE 129 ON READER-SERVICE CARD

TAURUS

PUNCHED CARD SENSORS



K-1000 **Reads Entire Punched Card Statically**

FOR

Simple Switching Using Standard Punched Cards

This Taurus Punched Card Sensor, with 1000 switches, is programmed by a special Taurus card made of mylar.*

Each hole position has a corresponding closed switch, and each unpunched hole position has a corresponding open switch when the Sensor is actuated. Used for Automatic Test Equipment and other automation devices.

Taurus also produces a complete line of Standoff and Feedthru Terminals insulated with Teflon*.

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CIRCLE 130 ON READER-SERVICE CARD

TEST EQUIPMENT

New line of precision meters and signal generators includes vacuum tube voltmeters and signal generators (shown), volt-ohm meters, VSWR indicators, and R-F power meters. Units feature wind-up power cord, fold-away handles, simplified front panel. —*Borg-Warner Controls, Box* 1679, *Santa Ana, Calif.*

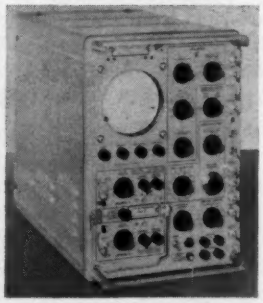
CIRCLE 311 ON READER-SERVICE CARD

COMPUTER TAPES

New 832 Series high-speed, high packing density Tape for computer systems exceeds 300,000 error-free passes on Ampex FR-300 digital tape transport at packing density of 556 bits/in, using heads compatible with other computer systems. Also, new 834 Series standard Tape exceeds 25,000 error-free passes on same tape transport system at 556 bits/in. Each reel of tape is 100% digital-inspected over entire useful length; certified error-free operation at packing density of 556 bits/in.—*Ampex Corp.*, 934 *Charter St., Redwood City, Calif.*

CIRCLE 312 ON READER-SERVICE CARD

OSCILLOSCOPE



New Type 945 environmentalized Oscilloscope with sweep-delay feature and Type MC Dual-Trace Preamplifier plugged into vertical channel permits highly precise measurements in dc-to-24 Mc region. Environmental capabilities include withstanding operating temp of —40° to 55°/71°C; 10 days at 95% RH, 18° to 65°C; 5-G vibration; 20,000' altitude (operating).—*Tektronix, Inc., Box* 500, *Beaverton, Ore.*

CIRCLE 313 ON READER-SERVICE CARD

20-MC COUNTERS

New portable Model 925 and rack-mounted Model 925-R solid-state 20-Mc Universal Counter-Timers measure frequency, period and time intervals; built-in memory provides read-out storage, continuous display while counting. Frequency range is dc-20 Mc; period, dc-100 kc; time interval, 0.3 μsec to 10^8 sec; accuracy is indicated at ±1 count ± time base stability for all operating modes.—*Erie-Pacific, Div. Erie Resistor Corp.*, 12932, *S. Weber Way, Hawthorne, Calif.*

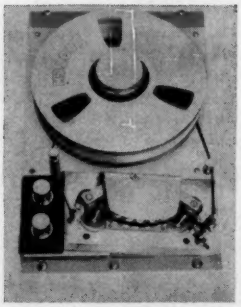
CIRCLE 314 ON READER-SERVICE CARD

DIGITAL VOLTMETER

New Model 550 Digital Voltmeter features range of 0.0001 to ±1200 v at accuracy of ±1 count, automatic polarity indication, effectively infinite input impedance, instantaneous reading. Modular unit uses new Borroughs long-life Nixie indicators and Beam-X switching tubes.—*Franklin Electronics Inc., Bridgeport, Pa.*

CIRCLE 315 ON READER-SERVICE CARD

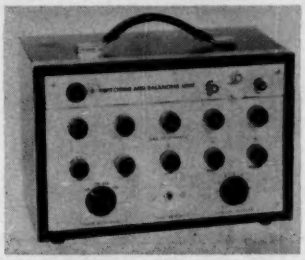
TAPE RECORDER



New Model M-101 concentric reel Instrumentation Magnetic Tape Recorder is "first low cost recorder that combines space saving advantage of concentric reel design with a low flutter characteristics of dual-differential capstan drive system." Transport handles standard 10½" NAB and precision reels of ¼", ½" or 1" tape. Micro-gap heads for high density recording are mounted on precision plate, are easily interchanged or replaced.—*American Concertone, Inc., Div. Astro-Science Corp.*, 9449 *W. Jefferson Blvd., Culver City, Calif.*

CIRCLE 316 ON READER-SERVICE CARD

SWITCHING, BALANCING UNIT



New 10-channel Type 525 Switching and Balancing Unit permits fast switching of strain gages or gage configurations into strain indicator. Provides individual gage bridge balancing, full and half bridge configurations, selectivity for gage resistances of 65-500 ohms on full bridge, 60-2000 ohms on half bridge, measurements during same test with both two- and four-arm bridges.—*Electronics & Instrumentation Div., Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass.*

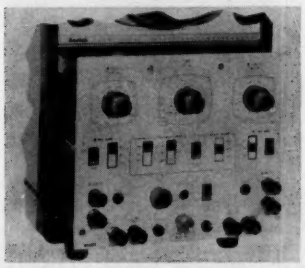
CIRCLE 317 ON READER-SERVICE CARD

COMPUTER MEMORY STORAGE

New "Microstore" analog computer stores answers or values to problems, can store two values at a time in one memory package for recall later. Up to 10 "Microstore" components, each containing two storage units, can be plugged into PACE 231R general purpose analog computer without disturbing use of existing summing amplifiers.—*Electronic Associates, Inc., Long Branch, N. J.*

CIRCLE 318 ON READER-SERVICE CARD

DUAL CHANNEL PLUG-IN



New Type 300 dual-channel Plug-In provides dc to 500-kc bandwidth and 1-mv/cm maximum sensitivity on both channels, has built-in trigger and sweep circuit, two amplifier channels. It provides single-ended or differential amplifier input, with high common mode rejection that may be optimized with separate adjustment for particular frequencies.—*Analab Instrument Corp., Cedar Grove, N. J.*

CIRCLE 319 ON READER-SERVICE CARD

value...

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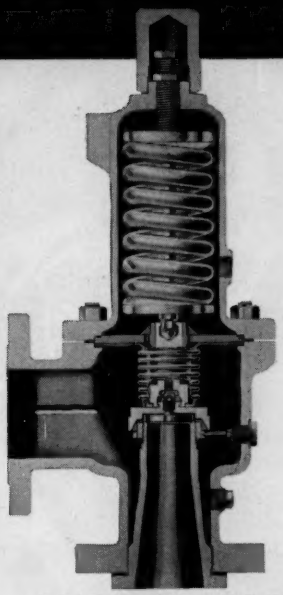


Series 2600 . . Balan-Seal bellows. 150 to 6000 psig. Also without bellows.

Farris Process Safety-Relief valves have unique design features which provide product serviceability and dependability unmatched by *any* competitive valve. True value is "built into" Farris valves.

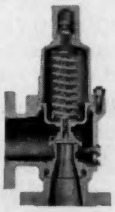
- **2½ to 1 ratio—guide length to guide diameter—prevents galling and hanging up.**
- **High thermal expansion of sleeve guide and low thermal expansion of hardened stem retainer stops binding at high temperatures.**
- **Hardened stainless steel optically lapped disc . . . self aligning for maximum tightness.**
- **Elimination of effects of back pressure by "BALAN-SEAL" bellows permits use of smaller discharge piping . . . Saves up to 15 times the cost of the valves . . . isolates internal working parts from lading fluid.**
- **Industry's most complete line. Available in cast iron, steel and special materials. Sizes ½" to 8". Pressures to 10,000 psig. Temperatures to 900°F. Enclosed or exposed springs. Plain, open lever or packed lever construction.**

All Farris Nozzle Valves Conform To ASME Power Boiler Code, Section 1, and The ASME Unfired Pressure Vessel Code, Section 8.

Series 2740 & 2741 . . . simple, rugged cast steel design. Pressures to 5000 psig @ 750°F.

Series 2745 . . . Durable, compact, high pressure nozzle valve. Internal parts 316 stainless steel. Pressures to 10,000 psig.

Series 2950 . . . Cast iron valve similar to Series 2600. Max. pressure 250 psig. @ 450°F, 400 psig. @ 150°F.



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Taber transducers probe rocket engine performance at Bell

The ruggedness, reliability and versatility of Taber Teledyne pressure transducers are amply demonstrated here. In this Bell Aerosystems' rocket engine test, six Taber bonded strain gage transducers are measuring chamber, hydraulic, valve actuation, tank, fuel and oxidizer pressures.

Three of the instruments (C, D, and F) have been in service at Bell for *more than 7 years!* The others are more current compact designs.

Taber transducers are available in a wide variety of models for test, ground support and airborne applications in pressure ranges from 0-50 to 0-10,000 psi. High frequency response, minimum hysteresis, infinite resolution and low sensitivity to temperature effects, vibration and shock are among their many plus features.

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DIGITAL VOLTMETER

New EItronic 848 4-digit, transistorized DC Voltmeter/Ratiometer measures d-c voltages or d-c ratios within ±1 digit with provisions for directly driving digital printer. Decimal point placement and signal polarity are determined automatically, are displayed with digital value of input voltage on 3-position tilting readout. —*Electro Instruments, Inc.*, 8611 *Balboa Ave., San Diego* 11, *Calif.*

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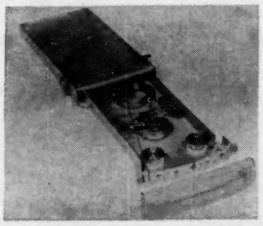
PNEUMATIC RECEIVER



New Selecto-Scale Receiver provides multiple scales in one instrument. Scales are printed on 4½" x 84" laminated "dead stretch" mylar tape, stored on spools, ready for easy positioning on dial face when change in process requires new scale values. Red set-hand clips onto dial, aligns as required.—*United States Gauge Div., American Machine & Metals, Inc., Sellersville, Pa.*

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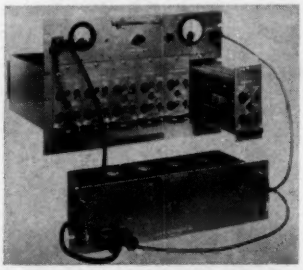
STRAIN GAGE CONDITIOINER



New Model 1-400 Servomatic Modular Strain Gage and Transducer Input Conditioner accommodates any type of resistance strain gage or transducer. Each module contains own floating power supply; depression of one pushbutton causes automatic servo balancing and automatic setting of sensitivity control. System nulls to ±10 μv; manual override provides normal manual balancing and voltage selection.—*B & F Instruments, Inc.*, 3644 *N. Lawrence St., Phila.* 40, *Pa.*

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STRAIN-GAGE PRESS TRANSDUCER

New 3S-G low-level-output silicon-semiconductor Strain-Gage Pressure Transducer provides 50-mv d-c signal, features high accuracy, infinite resolution, frequency response flat to 6 kc, and built-in temperature compensation. Having self-contained calibration and unexcelled repeatability, it responds accurately to both static and high-frequency dynamic pressures, and is fully compatible with existing military and industrial systems.—*Fairchild Controls Corp.*, 6111 *E. Washington Blvd., Los Angeles, Calif.*

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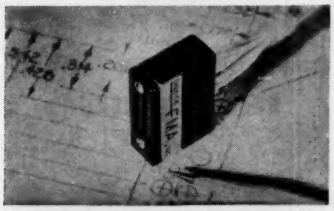
MINI DIGITAL RECORDING HEAD



New Digital Recording Head for correlating digital data and photographic images on same photographic film mounts inside camera, eliminates problem of synchronizing and collating several recording media. Converts transducer signals to code suitable for digital photo recording. Code readout and display are manual or automatic.—*FMA, Inc.*, 142 *Nevada St., El Segundo, Calif.*

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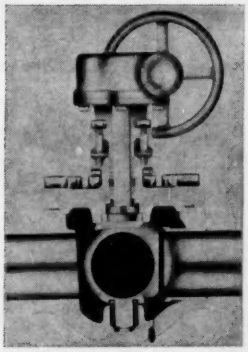
HI-TEMP BALL VALVE



New Ludeman Rotoflo Valve features eccentric cam action of stem to lift ball away from seat before it is turned, eliminating sliding friction. Permits use of hard metal-to-metal seating surfaces assuring tight shut-off, use at high temperature and under radioactive conditions.—*General Kinetics Corp.*, 197 *S. Van Brunt St., Englewood, N. J.*

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REC's new literature on temperature and pressure sensors and accessory equipment

If you have anything to do with the accurate measurement of temperatures or pressures, there is information of value to you in this collection of REC technical literature. Check the list below and send for the items that interest you.

Platinum Temperature Sensors

7617 Immersion Temperature Sensors

Air Data Sensors

7597 Model 102 Series Total Temperature Probes

126027 Total Temperature Probes

15811 Model 103 Total Temperature Probe

116010 Aerodynamically Compensated and Conventional Pitot Static Tubes

46024 Model 803A Static Pressure Port Calibrator

Pressure

36010 Model 800 Series Pressure Transducers

46027 Model 802A Reference Pressure Cell

Accessory Equipment

86012 Triple-Bridge, Multi-Channel Temperature Measurement System

5611 Vibration Isolation Table

7616 Dry Circuit Relay

36113 Mechanical Joint for Applications to Joining Materials of Different Expansion, Bearings which will not freeze at extremely high or low temperatures, rotating seals for extremes of temperature, etc.

Aeronautical Research

106021 REC Transonic Wind Tunnel Facility and Icing Wind Tunnel Facility

Technical Bulletins, Preprints

106017 Time Constant and Self-Heating Effect for Temperature Probes in Moving Fluids

116017, Rev. A Measurement of Mean Temperature in a Duct

7619 Methods of Measuring Temperature Sensor Time Constant and Self-Heating

NY60-91 Temperature Sensing from Aircraft with Immersion Sensors

B. 7.4 Some Recent Developments in Applied Platinum Resistance Thermometry

10605, Rev. B **Temperature Conversion Chart**

66030 **REC Short Form Catalog**

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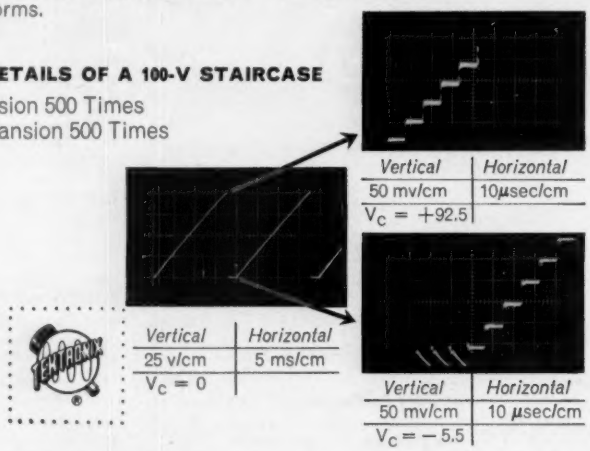
New differential plug-in preamplifier rejects up to 100 v of an input signal . . . accepts 100-v waveforms for oscilloscope display at 50-mv/cm sensitivity . . . provides an equivalent vertical scale length of ±2000 centimeters.

You can now display small segments of large waveforms at maximum oscilloscope sensitivity, with vertical expansion equivalent to as much as 500 times. You can select magnified "window" displays of all portions of a waveform, and make amplitude measurements with a degree of accuracy that closely approaches the possibilities of digital techniques. The flexibility and simplicity of the analog (oscilloscope) presentation is retained for accurate analyses of complex waveforms.

WAVEFORM DETAILS OF A 100-V STAIRCASE

Vertical Expansion 500 Times
Horizontal Expansion 500 Times



The new Type Z Plug-In Unit is a triple-purpose device, acting also as a conventional preamplifier and a differential-input preamplifier.It plugs directly into all Tektronix Type 530, 540, and 550 Series Oscilloscopes and fits into the Type 81 Plug-In Adapter for use with the Tektronix Type 580 Series Oscilloscopes.

Type Z Plug-In Unit f.o.b. factory **$525**

For a demonstration of the dynamic range, waveform resolution, and amplitude accuracy of the Type Z Unit in your own application, please call your Tektronix Field Engineer.

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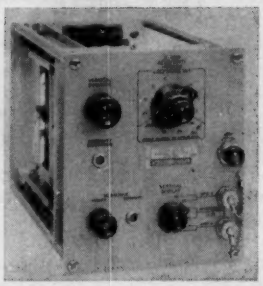
HIGH GAIN AMPLIFIER



New high-gain Amplifier, Model 162D, plug-in unit designed for Models 160B and 170A oscilloscopes, combines high common mode rejection with 5 mv/cm sensitivity and low drift. Has 12 calibrated ranges 5 mv/cm to 20 v/cm; vernier provides continuous adjustment between ranges, extends minimum sensitivity to at least 50 v/cm. At maximum sensitivity, 162D/170A combination has rise time less than 10 nsec; 162D/160B combination, less than 29 nsec. —*Hewlett-Packard Co.*, 1501 *Page Mill Rd., Palo Alto, Calif.*

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DECADE RESISTORS

New Dekabox Decade Resistor Boxes provide in-line digital read-out in four, five, or six decades with resolutions of 100 milliohms, 1, 10 and 100 ohms per step. Individual resistors have temp coefficient of ±10 ppm/°C above 100 ohms, ±20 ppm/°C below 100 ohms. Accuracy of adjustment of decades is ±(0.03% + 1 milliohm/decade); total zero resistance of each box less than 20 milliohms.—*Electro Scientific Industries (formerly Electro Measurements), 7524 S. W. Macadam Ave., Portland 19, Ore.*

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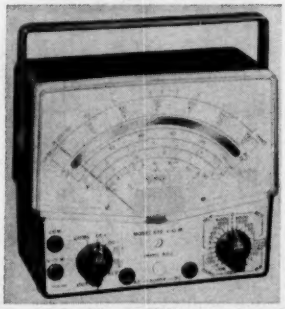
V-O-M



New Volt-Ohm-Milliammeter, Model 800, has 70 ranges and features frequency compensation from 40 cps to 20 kc, overload protection, 20,000 ohms/vdc and 10,000 ohms/vac sensitivity.—*Triplett Electrical Instrument Co., Bluffton, Ohio.*

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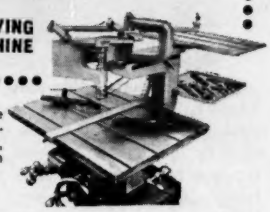
how to ENGRAVE PANELS & SIGNS to 30" wide by any length

Use the **LOW COST** *precision built* **PREIS-PANTO 2D-4**

ENGRAVING MACHINE



It does the work of larger machines, costing much more.

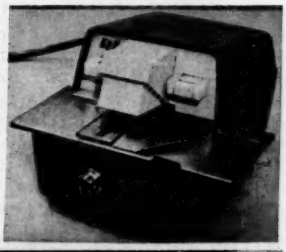
- Pantograph is graduated with reductions from 1:1 to 100:1 and will reduce to any size to infinity.
- Pantograph and spindle link joints equipped with precision ball bearings throughout.
- Precision ball bearing cutter spindle.
- Collet capacity from 1/10" to 1/4" and standard taper shank cutters.
- Six spindle speeds—5,000 to 14,000 rpm.
- All feed-screw dials graduated in .001".

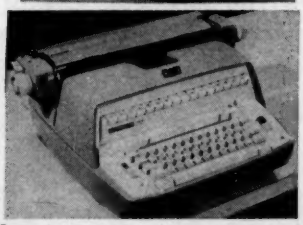
TRADE MARK PANTO

Write for complete details and prices. For immediate attention write directly to manufacturer below. Ask for nearest representative.

H. P. PREIS ENGRAVING MACHINE CO.
661 U. S. Highway 22, Hillside, N. J.
CIRCLE 135 ON READER-SERVICE CARD

DATA-PROCESSING COMPONENTS

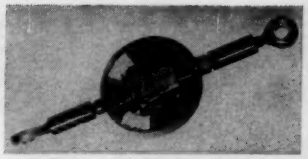




New data-processing-system components include photoelectric readers, punches, and electronic input-output typewriters. Photo-electric reader component (top) handles 5-8-channel punched paper tape or edge punched cards at rate of 30 characters/sec. Heavy duty electronic typewriter (bottom) serves as input-output device, has 16-key illuminated control panel, conventional electric typewriter keyboard.—*Smith-Corona Marchant, Inc., Data Processing Technical Sales,* 410 *Park Ave., New York* 22, *N. Y.*

CIRCLE 329 ON READER-SERVICE CARD

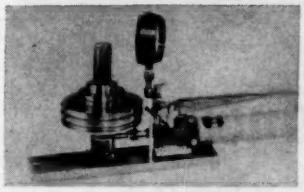
LOAD CELLS



New Load Cells measure tension and compression with full-load ratings of 1000, 2000, 5000, 10,000, 20,000, 50,000, and 100,000 lb. Units rated as low as 100 lb or as high as 500,000 lb are available on special order. Sensing is by resistance wire-type high-temperature weldable strain gages in bridge configuration within a ring. Bridge impedance is 120 ohms, input voltage 10 v; nominal output voltage is 25 mv full scale with 10-v input; linearity and hysteresis are both within 0.2%. Total errors from all causes is less than ±2% over temp range of −65° to 600°F.—*Microdot, Inc.,* 220 *Pasadena Ave., South Pasadena, Calif.*

CIRCLE 330 ON READER-SERVICE CARD

PRESSURE TESTERS



New Pressure Testers Types T and TQ operate with distilled water to avoid contamination of pressure instruments. Not just gage testers, they serve four purposes: general purpose hydrostatic testing; comparator testing with test gages; dead weight testing; and as dead weight gages. Thirteen types available, all rated for working pressures to 13,000 psi.—*Mansfield & Green, Inc.,* 6185 *Cochrand Rd., Cleveland* 39, *Ohio.*

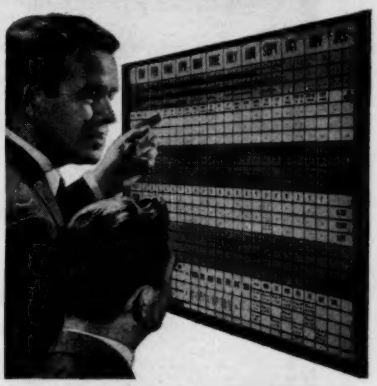
CIRCLE 331 ON READER-SERVICE CARD

HIGH-SPEED PULSE CODE

New Dynacode high-speed simple-channel Telemetering System for liquid level, temperature, and P.D.M. is based on pulse code system, gathers and digitally displays data in 3 sec. Illuminated in-line data display includes both point and function identification, digital data to six significant figures and liquid level to $\frac{1}{16}$" increments. Solid-state components are used.—*Dynel, Inc., Subs. of Varec, Inc.,* 12923 *Spring St., Los Angeles* 61, *Calif.*

CIRCLE 332 ON READER-SERVICE CARD

How To Get Things Done Better And Faster



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- ☆ Gives Graphic Picture—Saves Time, Saves Money, Prevents Errors
- ☆ Simple to operate—Type or Write on Cards, Snap in Grooves
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Yanceyville, North Carolina
CIRCLE 136 ON READER-SERVICE CARD

Readouts that do more...

Series 80000

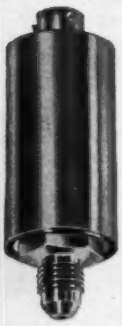
DISPLAY NUMBERS, WORDS, COLOR, and SYMBOLS

Features the largest readout area (7⅞ sq. in.) employing these applications. Price complete from $33.00. Your inquiry regarding readouts that do more, for you, is invited.

INDUSTRIAL ELECTRONIC ENGINEERS, INC.
8528 Vineland Ave., North Hollywood, Calif.

CIRCLE 137 ON READER-SERVICE CARD

A Transducer Two Years Ahead of its Time



A completely new patented pressure sensor concept has been utilized in Servonic's new, low pressure L-96 Transducer. This miniature potentiometer-type unit withstands vibration levels in excess of 35 g's with less than 1% error. Two separate sets of aneroid capsules attached to opposite ends of a driving frame are utilized in the design. One set senses the driving media while the second can be evacuated for an absolute pressure reference, or vented to the atmosphere for gage measurement.

Pressure changes are transmitted through a unique, frictionless, metallic belt linkage system to position the wiper of the precision potentiometer. The fluid filled interior dampens vibration effect, provides long life and minimizes electrical noise. The unit is so insensitive to vibrations, extended dwells are allowed at any vibration frequency. Besides its excellent vibration characteristics, the L-96 has a temperature range of −65° to 275° F and a range of 0-15 to 0-350 psia or g.

For additional information about the wide pressure ranges and mounting configurations available in the L-96, write:

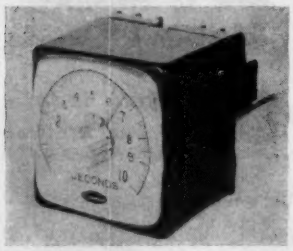
SERVONIC INSTRUMENTS, INC.

Manufacturers of pressure transducers, pressure switches, rectilinear potentiometers and slip ring assemblies.

1644 WHITTIER AVENUE, COSTA MESA, CALIFORNIA

CIRCLE 138 ON READER-SERVICE CARD

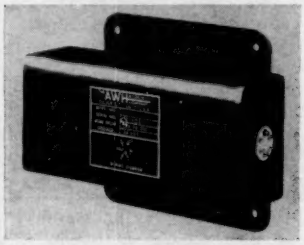
ELECTRONIC TIMER



New Cramer Type 940 Electronic Timer, transistorized general-purpose unit, has full-scale time ranges of 0.1, 1, 10 and 100 sec, with three models for choice of use as interval timer, time delay relay, or cycling timer. Employs novel circuitry to eliminate recycling error, has repeat accuracy of 1% of full scale.—*Cramer Div., Giannini Controls Corp., Centerbrook, Conn.*

CIRCLE 333 ON READER-SERVICE CARD

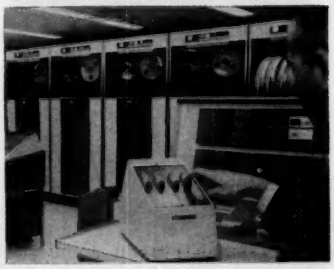
ELECTRONIC TIMER



New hermetically-sealed 31800 Series Precision Electronic Time Delay Relay with accuracy to 0.01%, and with time delay range from 50 msec to infinity, is rated at 30 G for shock, and 500 cps at 10 G for vibration. Contact arrangements range from SPST to 4PDT while contact rating at 28 v dc or 115 ac can be 10 amp resistive, 5 amp inductive; or 5 amp resistive, 3 amp inductive; or 2 amp resistive, 1 amp. ind.—*A. W. Haydon Co., Culver City, Calif.*

CIRCLE 334 ON READER-SERVICE CARD

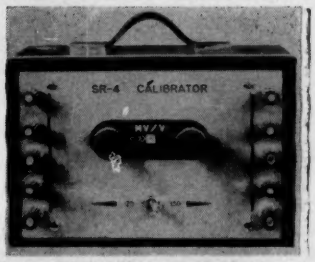
SWITCH CONTROL CONSOLE



New IBM 7155 Switch Control Console makes possible quick switching of magnetic tape unit's "affiliation" between two computers, between two tape channels of single computers, or between computer and auxiliary tape input/output system. Controls up to eight IBM 729 II or IV magnetic tape units.—*International Business Machines Corp., Data Processing Div., 112 E. Post Rd., White Plains, N. Y.*

CIRCLE 335 ON READER-SERVICE CARD

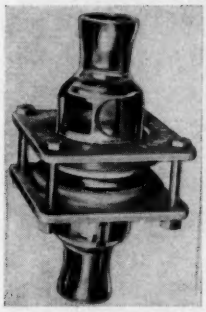
TRANSDUCER CALIBRATOR



New SR-4 Universal Instrument Calibrator checks with high accuracy overall performance of transducers, etc. providing 55 precision mv/v output signals (five different ranges with 11 points per range). Each point is accurate to 0.1%, or ±0.0003 mv/v, whichever is greater.—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., 42 Fourth Ave., Waltham 54, Mass.*

CIRCLE 336 ON READER-SERVICE CARD

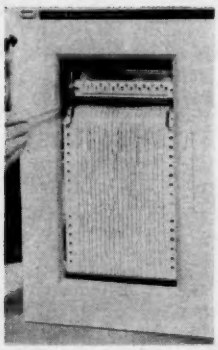
CHECK VALVE



New spring-loaded Check Valve Model SL200 features all-Pyrex-and-Teflon construction for full visibility with excellent corrosion resistance to all liquids except hydrofluoric acid and hot concentrated caustics. Positive sealing guaranteed by patented lip seal on seat; unique body design provides high flow rates at low pressure drop.—*Chem Flow Corp., 117 Patterson Ave., Little Falls, N. J.*

CIRCLE 337 ON READER-SERVICE CARD

INKLESS EVENT RECORDER



New 620 Event Recorder with Tempen, made as 10-channel or 20-channel model can operate more than 50 days without a change in charts. Using an electrically-heated stainless stylus for more than 20 years of continuous operation they have response speed of 1/20 sec. Special chart paper has a non-wax finish.—*Esterline-Angus Instrument Co., Inc., Box 596, Indianapolis 6, Ind.*

CIRCLE 338 ON READER-SERVICE CARD

For saving benefits to manufacturer and user

UNIFORMITY • SINGLE SOURCE
HIGH ACCURACY • LESS MAINTENANCE
LOW INITIAL COST • LESS DOWNTIME

standardize on the

ATCOTROL
LINE OF 9 TIMERS AND COUNTERS

AUTOMATIC RESET TIMER 305B	Up to 7 load circuits 16 standard dial ranges 14 point terminal block	*bulletin N-305B*
PUSH BUTTON RESET TIMER 309	1 or 2 SPDT load switches Best for batch control Cycle progress indication	*bulletin N-309*
TRANSISTOR TIMER 308	Long, dependable life .03—1.5 sec. to 1—150 secs. Remote dial setting	*bulletin 1001*
DUO-SET TWO CYCLE DIAL TIMER 306	Two circuits, independently adjusted Safety dwell between reversals Full scale adjustability	*bulletin N-306*
PERCENTAGE DIAL TIMER 304	Heavy, 25 amp contacts Integral on-off switch provides adjustable rate control	*bulletin N-304*
REVOLUTION COUNTER 307	Counts shaft revolutions Long-life piece counting Cut-off control	*bulletin 1000*
PUSH BUTTON REVOLUTION COUNTER 312	Count control for rotating shafts From 0—12 to 0—240,000 revs at 2000 rpm	*bulletin 1064*
IMPULSE RESET COUNTER 310	500 counts per minute Exclusive impulse motor principle Accurate count selection	*bulletin N-310*
PUSH BUTTON IMPULSE COUNTER 311	Ranges 2—120, 4—240, 5—480, 10—960 For batch counting control 500 counts per minute	*bulletin 1063*

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Quick Delivery—for your convenience, stocks of ATC Counters and Timers are maintained in principal cities for off-the-shelf delivery.

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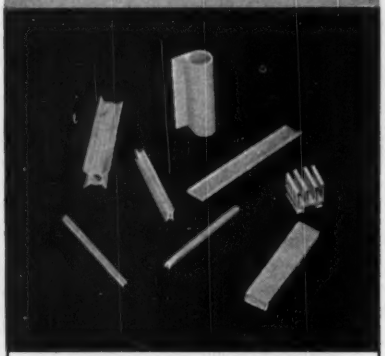
CIRCLE 139 ON READER-SERVICE CARD

NO MOLDS—NO WASTE
NO MACHINING

PF EXTRUDED
TEFLON*
SHAPES
Reduce Cost of Components
for electrical applications



Some of the many shapes extruded by Pennsylvania Fluorocarbon for the electrical and electronic industries include: shaped insulators, spacers, supporting channels and terminals.

These shapes offer:

- a dielectric strength from 500 to 2000 volts/mil.
- stability—no change of electrical properties with temperature (-25° C. to +250°C.) or frequency (60 cycles to 100 mc)
- zero moisture absorption
- a continuous service temperature range of 250°C.—intermittent to 300°C.

Extreme Dimensional Accuracy Assured On Any Appropriate Design

PF extruded shapes made from Teflon allow design engineers to incorporate the dielectric strength of Teflon into their products for electrical and electronic applications, economically. PF extrudes intricate Teflon shapes to extremely close tolerances, cuts them to lengths, post forms to requirements and performs any auxiliary machining steps. Molds are eliminated, there is no waste of Teflon and, frequently, no additional finishing operations are necessary. Result? Teflon components of extreme accuracy at lower cost.

Write, wire or call for a quotation on your particular Teflon component requirements, regardless of the intricacy of the shape. Shapes ranging from 2500 feet per pound to 6 feet per pound can be extruded.

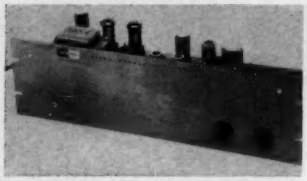
PENNSYLVANIA FLUOROCARBON CO., INC.

1115 N. 38th Street, Phila. 4, Pa.
EVergreen 6-0603 TWX: PH 252

*Du Pont registered trademark

CIRCLE 140 ON READER-SERVICE CARD

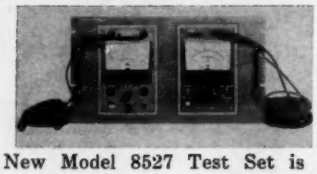
CLOSED-CIRCUIT TV



Three new Wideband Accessories for transmission of closed-circuit TV signals over long distances are: AVM-3 video modulator; AVD-3 video demodulator, and AVA-1, VHF amplifier: Model AVM-3 converts video signal to modulated r-f signal at one of four VHF crystal-controlled carrier frequencies; AVM-3 modulator is closed-circuit (non-radiating), single-sideband crystal-controlled transmitter; AVD-3 demodulator is super-heterodyne receiver capable of providing video output signals up to 1.4 v, flat to 8 Mc within ±1 db. AVA-1 is amplifier providing approximately 30 db of gain over frequency band covered by four VHF channels.—*Kin Tel Div., Cohu Electronics, Inc., Box 623, San Diego 12, Calif.*

CIRCLE 339 ON READER-SERVICE CARD

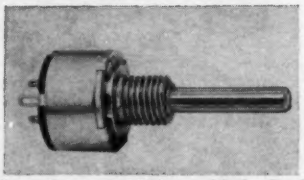
VOLTAGE/INSULATION TESTER



New Model 8527 Test Set is for high voltage breakdown tests and insulation leakage measurements. Hypot section provides a-c potential continuously variable from zero to 1.5 kv for breakdown testing. Vibrotest megohmmeter section measures insulation resistance to 50,000 megohms. Models available for measuring insulation resistance to 5 million megohms.—*Associated Research, Inc., 3777 W. Belmont Ave., Chicago, Ill.*

CIRCLE 340 ON READER-SERVICE CARD

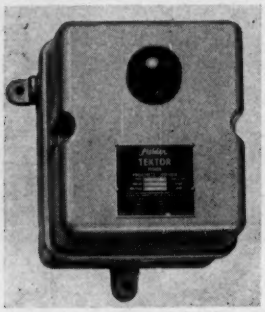
MOLDED CARBON POT



New Series 63M molded Carbon Potentiometer manufactured in accordance with MIL-R-94B, style RV-6, features improved performance and reliability. Unit is ½" dia, rated at ½ w at 70°C, derated to zero at 120°C. Resistance values range from 100 ohms to 5 megohms, with all values having linear tapers; resistance tolerance is ±10%; mechanical rotation 295° ±3°—*Clarostat Mfg. Co., Inc., Dover, N. H.*

CIRCLE 341 ON READER-SERVICE CARD

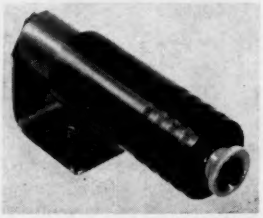
REMOTE LEVEL CONTROL



New development of high stability Tektor Level Controller enables remote control by use of up to 250' of coaxial cable between probe and instrument. Tektor consists of probe connected to electronic unit (probe installed on tank or container). Over 350 different probe types are available for liquids, powders or solids applications.—*Fielden Electronics, Inc., East Neck Rd., Huntington, N. Y.*

CIRCLE 500 ON READER-SERVICE CARD

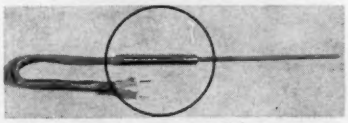
VERNIER PRESSURE REGULATOR



New A-53-A Vernator applies principle of varying volume to regulate pressure, "provides heretofore unavailable performance in pressure measuring." Features 10,000 to 1 dynamic pressure range, extreme sensitivity in setting any pressure from 0 to 500 psia. Unit is leak free with practically infinite resolution, it "obsoletes complex valving systems."—*Astromics, Div. Mitchell Camera Corp., 666 W. Harvard St., Glendale, Calif.*

CIRCLE 475 ON READER-SERVICE CARD

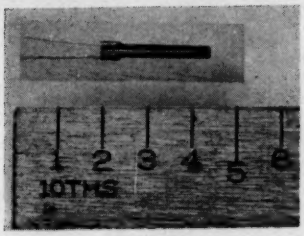
THERMOCOUPLES



New series of sensitive, rugged Thermocouples for temperatures to 1500°F features swaged adaptor to hold extension leads securely to sensing probe. Adaptor construction also features specially woven flexible stainless steel covering over lead wires, giving protection under rough service applications. Probes available in all calibrations.—Chromel/Alumel, iron/constantan, copper/constantan and platinum/platinum-rhodium.—*Hy-Cal Engineering, 12105 Los Nietos Rd., Santa Fe Springs, Calif.*

CIRCLE 496 ON READER-SERVICE CARD

U-SHAPED STRAIN GAGE



New U-shaped flexible, ultra-thin semiconductor Micro-Sensor Model MS632-120 strain gage features gage factor of 110 and leads on same end. Gage is proof-tested to 3000 microstrain, ultimate strain capacity of 5000 microstrain; resistance, 120 ohms; operational temp ranges from —320° to +400°F.—*Micro Systems, Inc.*, 319 *Agostino Rd., San Gabriel, Calif.*

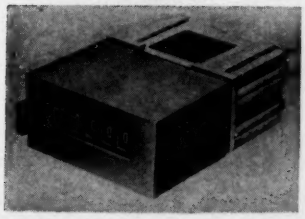
CIRCLE 472 ON READER-SERVICE CARD

INFRARED MONITOR

New Model PY40, in the Pyrotel line of non-contacting infrared radiation monitors and controls, operates in the range of 500-1200°F and higher, at distances of 12″ to many feet away from the targets, with repeat accuracies of 0.5%, and response in msec. Giving visual indication of relative temperature, it can also actuate power relays, and signal or control other machine equipment.—*Mason Instrument Co., Inc.*, 222 *Valley Place, Mamoroneck, N. Y.*

CIRCLE 473 ON READER-SERVICE CARD

COUNTERS

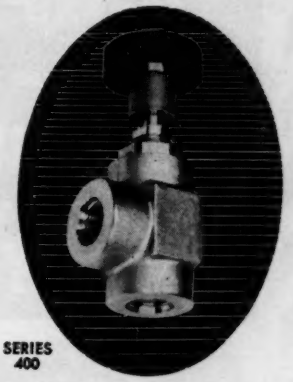


New line of Hengstler Counters includes Type CA magnetic or electrical impulse counter; Type CB, pre-determining counter; CC time counter; CD hand counter; CE and CF stroke and revolution counters, respectively; CG sheet counter for printing presses; CH revolution and ratchet counter; CI specialized counter for textile industry. Basic Type C Counter is illustrated.—*Rowan Controller Co., Red Bank, N. J.*

CIRCLE 474 ON READER-SERVICE CARD

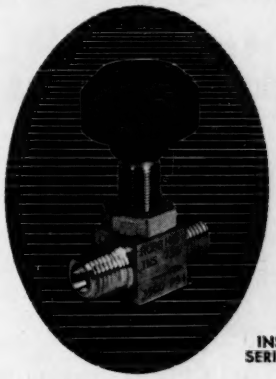
3 UNUSUAL VALVES BY ROBBINS

High Pressure
Slow Opening . . . Excellent Throttling
Up to 12000 PSI Operating Pressure
Rugged . . . Dependable
Pressure Balanced
Stainless Steel Throughout
Unique & Positive Sealing
Self Lubricating
Finger Tip Operating & Shutoff Torque
Both Liquid & Gas Service
Panel Mount in 1 Minute
Service Completely from Panel Front



SERIES 400

PRECISION MADE FOR PERFORMANCE!



INS SERIES

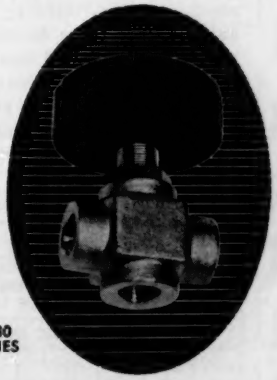
Instrument
Absolute Bubble-tight Shut-off
Low Torque . . . Finger Tip Control
Fine Metering Characteristics
Leakproof Operation
High Safety Factor
Male or Female Ports
As Light as .31 Lbs.
Brass or Stainless Steel
Hi-Vacuum to 3500 PSI
For Air-Nitrogen-Helium-Fuels-Hydraulic Oils-Water

DESIGNED TO SAVE YOU MONEY!

Three-Port
Hi-Vacuum to 6000 PSI

Versatile . . . May be used as a three-port valve with two ports in common, as a globe valve or as an angle valve. A relief valve, pressure gauge, or other device may also be installed in third port.

Simplifies Stocking Problems Stock 1, Serve Many!



T180 SERIES

When Costs of Replacement and Downtime Are Important . . . Specify ROBBINS!

ALL ROBBINS VALVES FEATURE 4 TO 1 BURST SAFETY FACTOR

Write TODAY for 16-page illustrated brochure in color

ROBBINS Aviation Inc.

3817 S. Santa Fe Ave.
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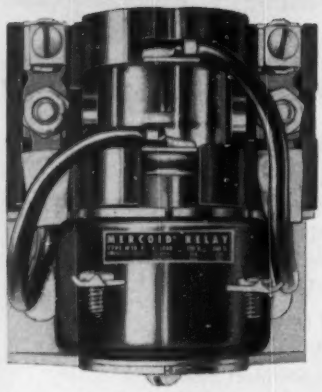
CIRCLE 181 ON READER-SERVICE CARD

35 AMP

Plunger Type

MERCOID MERCURY RELAY



If you need reliability and durability, this quality built relay by Mercoid is your answer.

For heavy duty loads, such as resistance heating, (domestic, commercial, industrial)—heat treating furnaces, drying equipment, welding, lighting, illuminated signs, score boards.

Hermetically sealed mercury to mercury contact provides visible on-off operation. Silent and chatterless. Quickly mounted, easily wired. Speeds up to 100 operations per minute.

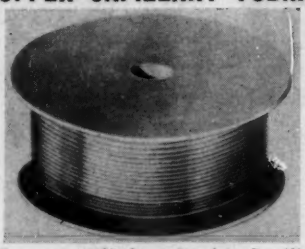
CONTACT RATING				
LOAD			NON INDUCTIVE HEATER LOADS	
	AC	DC	AC ONLY	
120V.	30A.	15A.	120V.	35A.
240V.	20A.	10A.	240V.	25A.
440V.	8A.	—	440V.	10A.

WRITE FOR BULLETIN 0-20

THE MERCOID CORPORATION,
4209 Belmont Ave.,
Chicago 41, Ill.

CIRCLE 144 ON READER-SERVICE CARD

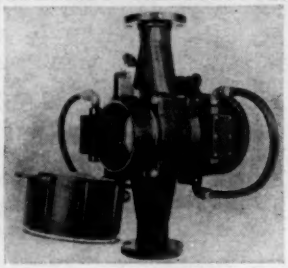
COPPER CAPILLARY TUBING



New controlled-grain-size Capillary Tubing—completely clean and free of residue inside and bright outside—is drawn, then the bore is rinsed with special solvent to remove all residue, oxide, scale, and drawing lubricant, and a vacuum annealing process removes last traces of solvent by vaporization. Made from copper ASTM B68, and B75 alloys in OD's 0.031" to 0.500", walls 0.004" to 0.040" in lengths up to 1000 ft (coils) or straight lengths ¼" to 15 ft with tolerances as narrow as 0.0005".—*Avins Industrial Products Corp.*, 50 *Broadway, New York* 4, *N. Y.*

CIRCLE 342 ON READER-SERVICE CARD

TURBIDITY TRANSMITTER



New Type UT1100A Turbidity Transmitter includes flow chamber, Bailey light source and Bailey balometer. Liquid passes through flow chamber which has two molded, heat-treated glass windows that are opposite each other. Radiant energy from light source passes through windows and through liquid to bolometer, which detects energy received from light source and produces electrical signal proportional to turbidity. —*Bailey Meter Co.*, 1050 *Ivanhoe Rd., Cleveland*, 10, *Ohio.*

CIRCLE 343 ON READER-SERVICE CARD

NOR CIRCUIT MODULES

New U-Series Universal NOR Circuits include (1) dual 3-input NOR unit; (2) power driver; (3) converter unit to convert dual NOR unit into either flip-flop, one-shot, or free-running multivibrator; and (4) pulse gate unit. Operate over frequency range 0 to 25 kc, meet MIL-specs.—*Engineered Electronics Co.*, 1441 *E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 344 ON READER-SERVICE CARD

ACHIEVEMENT IN PRECISION

Precision in design and manufacture is not sufficient to put your product up in the PRECISION orbit. Precision in thought, resulting in precision planning and organization is also required. This faculty which underlies our creative engineering, our craftsmanship and our manufacturing skill is our greatest resource. To this we owe our leadership in the design and manufacture of precision electrical, electro-mechanical and electronic products for the modern, ever-growing fields of instrumentation and automation.

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New York 10, N. Y.

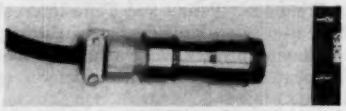
CIRCLE 199 ON READER-SERVICE CARD

D-C MICROVOLTAMMETER

New electronic (all-transistor) D-C Micro Volt-Ammeter (Model 4072, portable; Model 4072R, rack-mounted) is operated by an automatically-recharged nickel-cadmium battery. Full-scale ranges of voltage are from ±100 μv to ±1000 v, and current from ±10 muamp to ±1 amp. Accuracy on all ranges is ±1% full scale. Overload protection circuit makes it possible to safely apply up to 100 v on μv ranges, and 1000 v on upper ranges. Bulletin.—*Dynamics Instrumentation Co., 583 Monterey Pass Rd., Monterey Park, Calif.*

CIRCLE 345 ON READER-SERVICE CARD

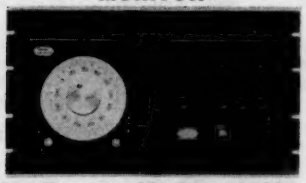
PRESSURE TRANSDUCERS



New 411 Series Ultradyne Pressure Transducers, available as gage, absolute and differential pressure measuring devices, provide nominal full-scale output of 200 mv with 2½% accuracy from −65° to 1,000°F. At room temperature accuracy is ½%; over any 250° span, 1%. Units offer full-scale measurements ranging from 0.6 to 5,000 psi, have high resistance to nuclear radiation.—*Consolidated Controls Corp., Bethel, Conn.*

CIRCLE 346 ON READER-SERVICE CARD

MONITOR



New Economy Monitor provides accurate, sensitive, low-cost monitoring of from one to ten points, to be checked for same value such as temperature, pressure, speed, pH, flow, etc., or any process variables measurable by transducers generating d-c millivolt outputs, or changes in resistance. Available with null-balance potentiometer or bridge-type measuring circuit and ten-point scanning mechanism. Each point to be monitored is scanned in sequence and its value compared to pre-established setpoint.—*Thermo Electric Co., Inc., Saddle Brook, N. J.*

CIRCLE 347 ON READER-SERVICE CARD

G-A CUSHIONED SOLENOID OPERATED VALVE

Where remote control valve operation is desired, specify and use the G-A Cushioned Solenoid Operated Valve that automatically opens or closes on any type of electrical impulse. The operating sequence—whether on open or closed circuit—can be made to suit your requirements. Sizes 2" to 36"

Bulletin W-7A has the complete story.

GOLDEN ANDERSON Valve Specialty Company

1286 RIDGE AVENUE, PITTSBURGH 33, PA.

Designers and Manufacturers of VALVES FOR AUTOMATION

CIRCLE 145 ON READER-SERVICE CARD

COMPUTING AUDIOMETER

New Inductive Decision Audiometer (IDA) combines standard audiometer, typewriter modified for audiological use, and computing system. It can be programmed to follow standard audiometric procedures or any variation in techniques desired. IDA varies frequency and gain of pure tone signals in graduated steps. Tone impulses emitted at irreguar intervals avoid response to rhythm pattern. Computing audiometer remembers subject's responses and makes audiological decisions, eliminates possibility of human error, automatically rechecks.—*Beltone Hearing Aid Co., 2900 W. 36 St., Chicago, Ill.*

CIRCLE 348 ON READER-SERVICE CARD

STOP Voltage DRIFT AND ELIMINATE FREQUENT RESTANDARDIZATION OF PRECISION POTENTIOMETERS!

USE THE *evenvolt* D.C. CURRENT SUPPLY

Replace Drifting Wet or Dry Batteries!

End Wet Cell Acid Hazard!

Use with L & N K2 or K3, M-H Rubicon Type B or Similar Laboratory Potentiometers

- **Input**—100-135 V AC 50-60 C
- **Output**—Volts: 1.4, 2.0, 2.5, 3.0, 4.0 or 6.0 V DC Nominal (Others Available)
  Current: 1.0, 8.0, 10.0, 11.0, 22.0, 24.44 or 25.00 Ma. (Others Available)
  Line Voltage Regulation: Maximum .01%
  Ripple: Max. 0.001%
  Isolation: Less than 1 mmfd. to line
  Temperature Coefficient: Less than 0.0005%/°C
- **Case**—18 Ga. steel, bonderized, enameled

OTHER EVENVOLT MODELS

Model 201 Reference Unit
Eliminates Batteries, Standardizing Circuit and Components

For Self-Balancing Potentiometers L & N, M-H, Bristol, Wheelco, West, Weston and others.

Battery Size For Mounting In All Instruments. Complete installation instructions included with each unit.

Model 300 DC Potential Source

For Calibrating, Self-Balancing and Manual-Balance Potentiometers and other instruments of high input impedance. For bucking potentials in electro-chemical measurements. Supplies isolated, adjustable, accurate, stable, DC Potential at 0-1000, 0-100, 0-50 MV.

Model 500 DC Regulated Power Supply

For Use As Power Supply For Strain Gages, Resistance Bridges; as voltage standards, filament source, etc. Supplies isolated, regulated, stable DC voltage 0-10 at currents up to 50 Ma.

Model 600 DC Voltage Reference Unit

For Use As Bucking Potential, Reference Voltage, etc. Supplies an isolated, accurate, stable voltage of 1.000, 1.019, 6.2, 8.4, 9.0, 9.3, 11.7 at currents of 0.5, 1.0, 10.0 Ma.

Representatives in All Principal Cities. Write for complete specifications and engineering data.

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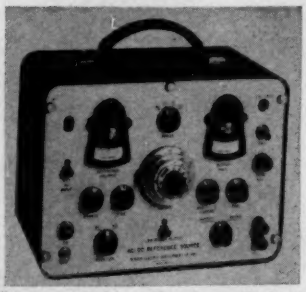
CIRCLE 146 ON READER-SERVICE CARD

PORTABLE REFERENCE SUPPLY



New portable Tensor Reference Supply Model 5890LW has prime application as accurate a-c/d-c voltage source for meter calibration, also for calibrating most a-c/d-c voltmeters, as source of power to 1 w, precise voltmeter in 0-100-v range, and as general source of a-c or d-c voltage. Accuracy is ±0.25% of set voltage above 0.01 v and ±0.20% of set voltage below 0.01 v.—*Tensor Electric Development Co., Inc.*, 1873 *Eastern Parkway, Brooklyn* 33, *N. Y.*

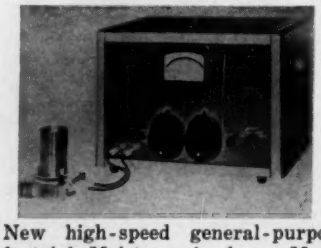
CIRCLE 349 ON READER-SERVICE CARD

ENGINE OPTIMUM CONTROL SYSTEM

New automatic Computer Control System controls speed and fuel-air mixture of gas engines, maintains optimum performance even during extreme changes in weather and atmosphere. System includes supervisory panel, speed control network, and pneumatic computer mixture control network.—*Bailey Meter Co.*, 1050 *Ivanhoe Rd., Cleveland* 10, *Ohio.*

CIRCLE 350 ON READER-SERVICE CARD

MOISTURE ANALYZER



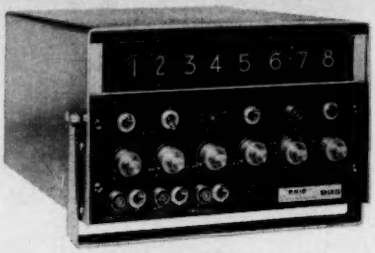
New high-speed general-purpose industrial Moisture Analyzer Model HFR-4E, designed especially for process or quality control systems employs new method of moisture determination by means of radio-frequency power absorption. Foolproof and simple to operate, it provides positive moisture control for processing plastics, foods, chemicals, drugs, paper, textiles, etc. Range is 0-80%; accuracy is 0.01% to 0.5%; it is non-destructive, unaffected by density of material, granual size, moisture gradient, or process temperature. Erroneous measurements due to capacitance are precluded.—*Boonton Polytechnic Co., Inc., Dept.* 111, *Box* 125, *Boonton, N. J.*

CIRCLE 351 ON READER-SERVICE CARD

ERIE *Instrumation*

MODEL 925

. . . the counter that remembers!!



SOLID STATE

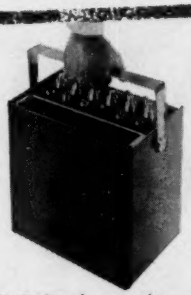
20 MC

UNIVERSAL COUNTER-TIMER

All new . . . the rugged, compact Model 925 is designed to offer the ultimate in reliable counting of periodic or random electrical events and precise measurement of Frequency, Period and Time Intervals. *Built-in memory* provides readout storage, continuous display while counting, more frequent sampling and less operator eye fatigue. Modular construction.

OUTSTANDING FEATURES:

- IN-LINE NIXIE READOUT
- 8 DIGIT MEMORY — No Blinking
- SENSITIVITY — .1V RMS — All 3 Channels
- THREE DC AMPLIFIERS
- HIGH INPUT IMPEDANCE
- AUTOMATIC DECIMAL POINT
- ONLY 3½" RACK SPACE (Model 925-R)
- DECADE TIME BASE — No Adjustments
- STABILITY — 1 Part In 10⁸/Day; 5 Parts In 10⁸/Week



ONE HAND PORTABILITY

Write today for complete specifications on the Model 925 or Model 925-R (Rack Model) — the ideal instrument for laboratory or industrial applications.

Quality Where It Counts
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ERIE PACIFIC, DIV. OF ERIE RESISTOR CORP.
12932 South Weber Way, Hawthorne, Calif.
ORegon 8 5418 • TWX HAW CAL 4006

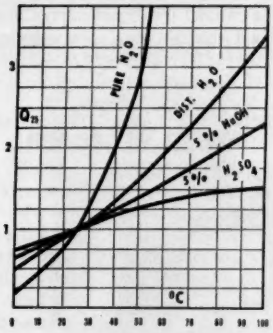
CIRCLE 147 ON READER-SERVICE CARD

CHATS ON CONDUCTIVITY

ACCURATE TEMPERATURE COMPENSATION

The overall accuracy of an electrolytic conductivity system is governed to a larger extent by the accuracy of its temperature compensator than by any other single factor...and probably ...by all other factors combined.

A prime requisite for high accuracy in conductivity measurements is a good match between the temperature coefficient of conductivity of the solution under test, and the characteristics of the temperature compensator. A small departure multiplied by a large number of °F can produce an impressively large error.



The above curve demonstrates the extent to which the temperature-conductivity characteristics of four common solutions differ from each other. Q_{25}, shown as the vertical coordinate, is the ratio of the conductivity of a solution at t°C to the conductivity of the same solution at 25°C. A temperature compensator designed to match any **one** of these solutions would fail miserably if used for any of the others.

Industrial Instruments, for many years, has recognized the need for close matching of the temperature compensator to the service requirements of the conductivity equipment. Over 500 different manual temperature compensators and 200 automatic temperature compensators are immediately available for applications ranging from ultra-pure demineralized water to fuming sulphuric acid, and from 20°F to above 300°F.

Industrial Instruments stands ready to serve you with authoritative information and the best in Electrolytic Conductivity Equipment...Electrolytic Conductivity is Our Business!

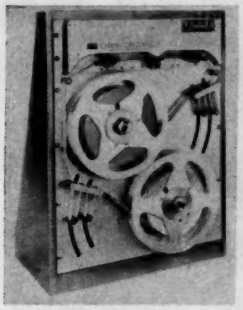
Solu Bridges...Continuous Indicators...Electrodeless Conductivity Systems...Battery-Operated Recorders...Larson-Lane Steam & Condensate Analyzers...Thallium Dissolved Oxygen Analyzers...Circular & Strip Chart Recorders...Conductivity Cells...Platinizing Kits & Supplies...Sample Coolers & Cell Holders...Therma Bridge Gas Analysis Equipment.

Industrial Instruments Inc.

89 Commerce Road Cedar Grove, Essex County, N. J.

CIRCLE 148 ON READER-SERVICE CARD

HIGH SPEED TAPE REELER



New Model RS-400 high speed bi-directional Tape Reeler operates at any tape speed with 8" or 10½" dia reels, in either direction to 60 ips, under tape reader control. Used with Omnitronics Tape Reader PTR-7 or PTR-71 or as modular unit permitting adaptation to other systems.—*Omnitronics, Inc., Subs. Borg-Warner,* 511 *N. Broad St., Phila.* 23, *Pa.*

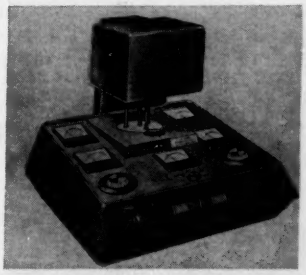
CIRCLE 352 ON READER-SERVICE CARD

MINI SHUT-OFF VALVE

New SSG106-2L miniature Shut-off Valve with positive bonnet lock is for oxygen, nitrogen, helium, air, fuels, hydraulic oils, and chemicals from high-vacuum to 3500-psig service, with shut-off torque of only 6 in-lb at 2000 psig.—*Robbins Aviation, Inc.,* 2350 *E. 38th St., Los Angeles* 58, *Calif.*

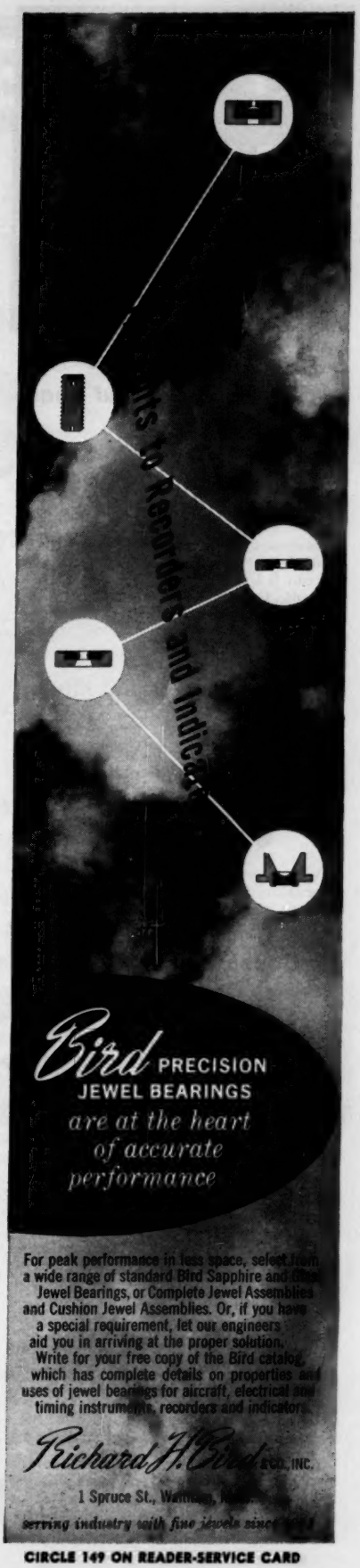
CIRCLE 353 ON READER-SERVICE CARD

THERMIONIC TEST CELL



New Model B103 Variable-Parameter Thermionic Converter, basic research tool for performing complete parametric studies in field of thermionic energy conversion, features replaceable emitter and collector, variable interelectrode spacing, and complete temperature controls and monitors. Unit uses electron-bombardment heat source; electrically isolated guard rings at interaction space provide control for studying and reducing fringe effects.—*Thermo Electron Engr. Corp.,* 85 *First Ave., Waltham* 54, *Mass.*

CIRCLE 354 ON READER-SERVICE CARD


Bird PRECISION
JEWEL BEARINGS
are at the heart
of accurate
performance
For peak performance in less space, select from a wide range of standard Bird Sapphire and Other Jewel Bearings, or Complete Jewel Assemblies and Cushion Jewel Assemblies. Or, if you have a special requirement, let our engineers aid you in arriving at the proper solution.
Write for your free copy of the Bird catalog, which has complete details on properties and uses of jewel bearings for aircraft, electrical and timing instruments, recorders and indicators.
Richard H. Bird & Co., INC.
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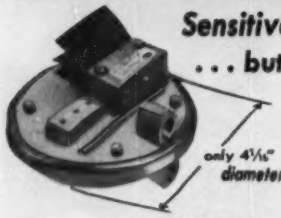
CIRCLE 149 ON READER-SERVICE CARD

Dwyer

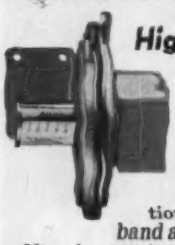
Differential Pressure Switches

for all your low range needs



Sensitive ... but small

Compact, low cost, highly sensitive to differential pressures in ranges from 0.15" to 80" water. Holds set point through various total pressures. Virtually unaffected by vibration. *Use in any position. 1800 Series.* Write for Bulletin E-40.



High Reliability...

Settings down to 0.05" water

Repetitive accuracy within 1% in pressure ranges too low for conventional switches. Dead *band as low as 0.03" water.* Visual set point, tamper proof calibration. No drift or hysteresis error. *High static pressures. 1630 Series.* Write for Bulletin E-30.

Double Circuit Control with Center Null Area

Dead band spans pressure control range—two micro-switches actuate separate circuits at high and low limits. Ranges from 0.15" to 24" water. *1627 Series.* Write for Bulletin E-20.

Variations For Special Applications

For example—open contact null type switch for controlling reversible blower motors . . . or for pressures up to 100 PSIG with range of 4" of w.c. differential pressure . . . engine intake air filter switches . . . high/low alarm actuation for telephone circuit tie-in . . . extremely-low-range magnetic double circuit switch for upper/lower environmental limit control.

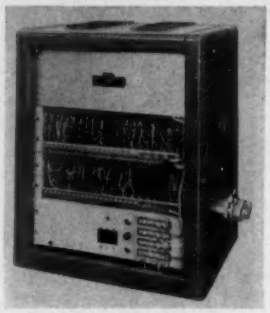
Give us details of *your* special low-range differential switch requirements. We'll recommend a pressure switch suited to your needs.

F. W. DWYER MFG. CO.

P.O. Box 373-S • Michigan City, Ind.

CIRCLE 150 ON READER-SERVICE CARD

DATA-RECORDING SYSTEM



New Data-recording System (delivered to Perkin-Elmer Corp. to record, for future reduction, data generated by firm's Model 221 Infrared Spectrophotometer) is built of S-PAC digital modules, accepts data from two shaft position digitizers and records it on high speed paper tape. Data is then recorded for further processing by general purpose computers, such as IBM 650.—*Computer Control Co., Inc., Western Div., 2251 Barry Ave., Los Angeles 64, Calif.*

CIRCLE 355 ON READER-SERVICE CARD

METAL-TUBE VAREA-METER

New line of metal-tube Variable-area Flow Meters to complement glass-tube Varea-meters is used at temperature and pressures beyond range of glass-tube type and for handling hazardous materials. Made in tube diameters from ½" to 3", water capacities from 1 to 400 gpm, and air capacities from 4.2 to 1680 scfm. Supplied with magnetic indicating extension, or optionally with transmitter to operate recorders, controllers or integrators.—*Wallace & Tiernan, Inc., 25 Main St., Belleville 9, N. J.*

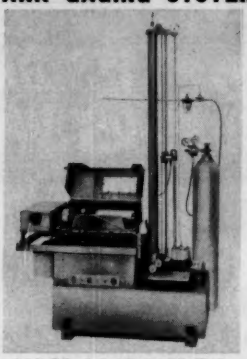
CIRCLE 356 ON READER-SERVICE CARD

CRYOGENIC THERMOMETER

New subminiature Cryogenic Thermometer Type CG-1 for measurement of temperatures in liquid helium range of 1.5 to 5.0° K is hermetically sealed unit with accuracy and repeatability better than ±0.050° K (with improvement to ±0.001° K expected soon). Thermometer element is properly doped germanium p-n resistance which measures approximately 235 ohms at 4.2° K with sensitivity greater than 50 ohms/°K. Mounted in glass-to-metal hermetically-sealed platinum enclosing case.—*Radiation Research Corp., 140 E. 59 St., New York 22, N. Y.*

CIRCLE 357 ON READER-SERVICE CARD

TANK GAGING SYSTEM



New 60" Model 15601N-F for measurement of tank level with multispan mechanical recorder, digital encoder and counter indicates level directly to five decimal places. Combination of Exactel Servomanometer with purge bubbler principle results in new technique. Process is one of weighing, rather than sensing surface level. Errors caused by temperature change, absorbed gases, etc., are eliminated. Uses transistorized servoamplifiers.—*Exactel Instrument Co., 185 Evelyn Ave., Mountain View, Calif.*

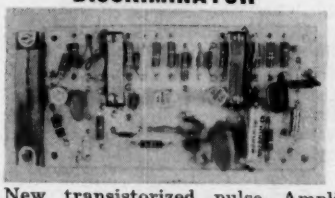
CIRCLE 358 ON READER-SERVICE CARD

POWER RECORDER

New dual-channel a-c Power Recorder records expanded scale a-c voltage simultaneously with a-c current by two individual galvanometers. 120 v/60 cycle standard, 2% rated accuracy, 25-500 cps frequency response.—*Rustrak Instrument Co., 130 Silver St., Manchester, N. H.*

CIRCLE 359 ON READER-SERVICE CARD

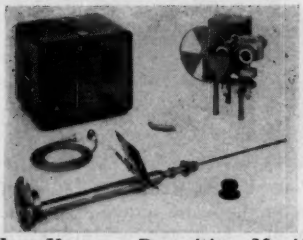
PULSE AMPLITUDE DISCRIMINATOR



New transistorized pulse Amplitude Discriminator and Pulse Shaper Model 15-ZHS-001, has input suitable for operation from pulse amplifiers and special pulse circuits, output utilized for analog integrating circuits (with meter or recorder) as well as digital counters and oscilloscopes. Applications include scintillation counters, proportional counters, neutron counters, pulse shaping for digital circuits and analog integration, and signal-noise discrimination. —*Franklin Systems, Inc., Box 3250, West Palm Beach, Fla.*

CIRCLE 360 ON READER-SERVICE CARD

DEPOSITION MONITORS



New Vacuum Deposition Monitoring System simplifies control of both dielectric and metal film depositions in production of optical and magnetic thin films and precision semiconductors. System consists of 90-cps chopped light source, mirror system and glass blank monitor disc, lead-sulfide detector cell with objective lens and filter wheel, and two-channel solid state amplifier-power supply to operate 10-mv recorders or meters. —*Optics Technology, Inc.*, 248 *Harbor Blvd., Belmont, Calif.*

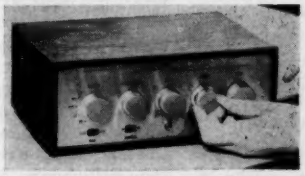
CIRCLE 361 ON READER-SERVICE CARD

TEMPERATURE CONTROLLER

New low-cost Pt Temperature Controller, a resistance-bulb signaling type, offers on-off or proportioning control over the range from −150° F to +1050°F. One probe handles all ranges. Features include transistorized circuitry, platinum resistance-thermometer sensing element, plug-in construction, and low power requirements.—*Technique Assocs., Div. Duncan Electric Co., Inc.*, 1413 *N. Cornell, Indianapolis* 2, *Ind.*

CIRCLE 362 ON READER-SERVICE CARD

TRANSISTORIZED AMPLIFIER

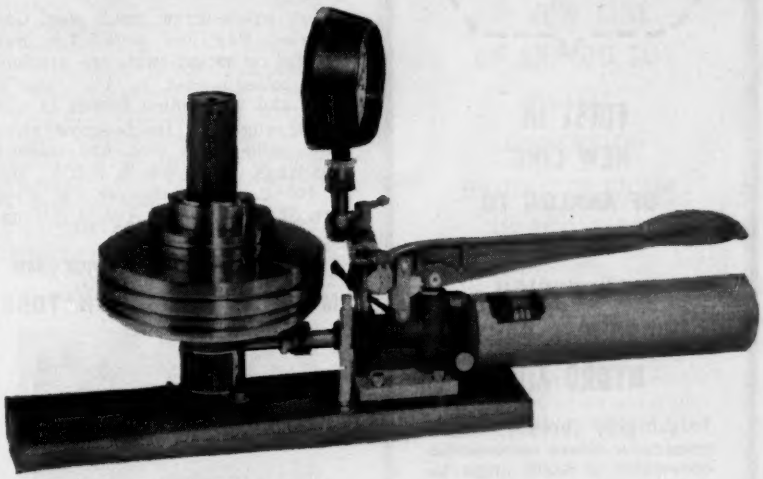


New all-transistorized Stereo Amplifier provides 20 w of sine-wave power per channel from a distortionless amplifier circuit. Has no filament hum, warm-up time, microphonics, or heat to deteriorate and change characteristic values of components, and adversely affect system performance.—*Texas Instruments, Inc., Box* 5012, *Semiconductor-Components Div., Dallas* 22, *Tex.*

CIRCLE 363 ON READER-SERVICE CARD

PRESSURE TESTERS

TYPE T
DISTILLED WATER SERVICE
TYPE R
OIL SERVICE
WORKING PRESSURES TO 13,000 PSI



FOUR testers in ONE unit

1. Portable pressure testing.
2. Comparator testing with test gages.
3. Dead weight testing.
4. Dead weight gage.

PLEASE REQUEST CATALOG 761

MANSFIELD & GREEN INC.
6185 Cochran Rd., Cleveland 39, Ohio

CIRCLE 151 ON READER-SERVICE CARD

ELECTRIC FLOW TRANSMITTER

New line of solid-state electric Rotameter Transmitters emits any of 5 d-c output signals to match most existing electric receivers or computers. Operating on induction principle, transmitter measures and transmits flow rates up to 200 gpm in pipelines up to 3", at pressures to 600 psig. —*Schutte and Koerting Co., Cornwells Heights, Bucks Co., Pa.*

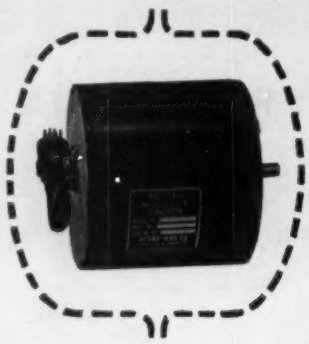
CIRCLE 364 ON READER-SERVICE CARD

DENSITY MEASURING DEVICE

New Densitor provides uniform and reproducible density determinations continuously in-stream, or by batch or sampling techniques. Non-destructive measurement of chemicals, foods, drugs, etc. Operates in −65° to 200° F, −15 to 200 psi ranges within 10 msec. Not affected by attitude of sensor, flow velocity, viscosity.—*Co-Engineering Co., Boonton, N. J.*

CIRCLE 365 ON READER-SERVICE CARD

PHOTOTRON



FIRST IN NEW LINE OF ANALOG TO DIGITAL CONVERSION PRODUCTS FROM HYDRO-AIRE

This highly versatile basic transducer offers incremental conversion of shaft angle to digital measurement. Available in seven models, its maximum permissible speeds range from 15,000 rpm at 128 counts per revolution to 1,250 rpm at 2,048 counts, with sample rates ranging to 45,000 counts per second.

Applications for the Hydro-Aire Phototron include analog to digital shaft converters, precision analog servo with digital readout, data reduction equipment, tachometers, and precision measurement and control.

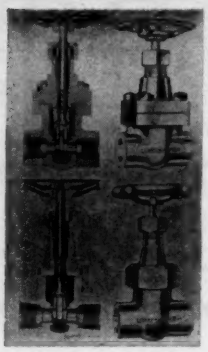
Detailed specifications are available on request. Related products soon to be available from Hydro-Aire, a member of the Crane Co. Systems and Controls Group, will include associated power supplies and binary and digital counters.

HYDRO-AIRE
DIVISION OF
CRANE

3000 WINONA AVE., BURBANK, CALIF.

CIRCLE 152 ON READER-SERVICE CARD

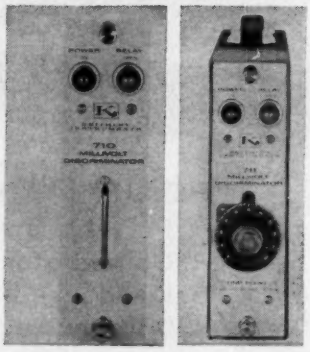
GATE VALVES



New inside-screw small steel Gate Valves, Figures 8004-5-7-8, have screwed or socket ends, are available with bolted-bonnet in 1½" and 2" sizes, and with union bonnet in sizes ¼" through 1". Inside-screw rising stem, solid-wedge disc, and rolled-in seat rings. Rated 800 lb, 850°F; 2000 lb, 100°F.—*Lunkenheimer Co., Beekman St. at Waverly Ave., Cincinnati 14, Ohio.*

CIRCLE 366 ON READER-SERVICE CARD

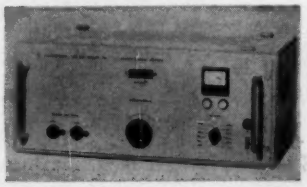
MILLIVOLT DISCRIMINATORS



Two new stable, light-modulator D-C Amplifiers, Models 710 and 711, are identical except for means of adjusting trip level from 0.2 to 10 mv. Uses include testing of diode and capacitor leakage currents, controlling temperatures, sorting resistors in automatic bridges, nuclear safety applications, etc.—*Keithley Instruments, 12415 Euclid Ave., Cleveland 6, Ohio.*

CIRCLE 367 ON READER-SERVICE CARD

FREQUENCY STANDARD



New Type XSA Frequency Standard has a guaranteed frequency drift below 5 x 10^{-10} day after thirty days of operation. Output frequencies are 1 Mc and 100 kc at 1-v levels.—*Rohde & Schwarz Sales Co., Inc., 111 Lexington Ave., Passaic, N. J.*

CIRCLE 368 ON READER-SERVICE CARD

REVERSIBLE COUNTER

New transistorized Reversible Counter has two inputs, A and B, each of which can operate at high speeds over frequency range of dc to 200 kc with input amplitude of from 1 to 10 v peak to peak in sine wave or square wave form. Unit adds and/or subtracts groups of pulses and/or square waves; 6-decade readout, nixie tubes available. Push button resets all decades to zero simultaneously; individual push buttons on each decade preset number into counter.—*Wang Laboratories, Inc., Natick, Mass.*

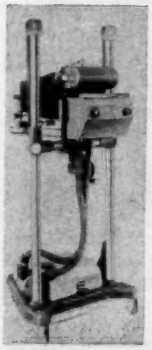
CIRCLE 369 ON READER-SERVICE CARD

TACHOMETER INDICATOR

New Model FR-85 Tachometer Indicator accepts output of tachometer generator, per MIL-G-9398A, and provides digital indication in % full RPM within ¼% from −40° to +130°F. Manual digital null-balance dial covers range of 50.0% to 110.0% RPM, can be read to better than 0.1% RPM. Bulletin 117.—*Waugh Engr. Co., 7842 Burnet Ave., Van Nuys, Calif.*

CIRCLE 370 ON READER-SERVICE CARD

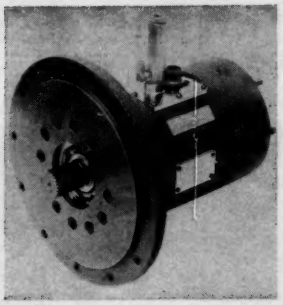
RAPID FILM PROCESS



New Ultra-Rapid System produces processed and dried film of extremely high resolution and detail in as little as 4½ sec after exposure. Equipment consists of camera, electric film drive, processing unit, and illuminated viewing screen (optional). Does not require wash-water supply, operates anywhere with 110-v current. View camera with rapid processing for commercial and industrial uses is shown.—*Ansco Div., General Aniline & Film Corp., Binghamton, N. Y.*

CIRCLE 371 ON READER-SERVICE CARD

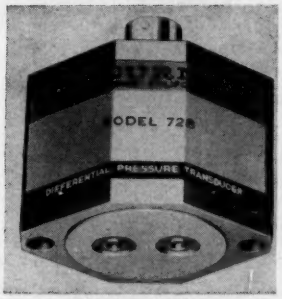
TORQUE TRANSDUCERS



New Torquometers are constructed to support large loads, mate with hydraulic pumps, generators and starters, are useful on test stand applications for rapidly changing device under test. Model CB3-10D has 10" bolt circle on drive end; Model CB3-10DL, on both load and drive ends.—*B & F Instruments, Inc., 3644 N. Lawrence St., Phila. 40, Pa.*

CIRCLE 372 ON READER-SERVICE CARD

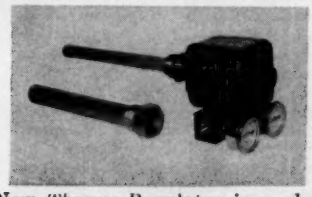
D-P TRANSDUCER



New Model 728 Differential-Pressure Transducer uses precision Ni-Span-C spiral bourdon tube and special isolation bellows to give full complement of zero-centered pressure ranges with low error (1.3%). Precision platinum alloy wire potentiometer element matches bourdon tube to compensate for tube non-linearities. Features direct mounting, ±400 to ±3500 psid range.—*Bourns, Inc., 6135 Magnolia Ave., Riverside, Calif.*

CIRCLE 373 ON READER-SERVICE CARD

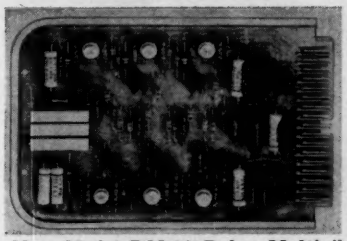
TEMPERATURE CONTROLLER



New Thermo-Regulator is a glass-metal type Controller with a pre-set point. Models are available to provide either pilot- or direct-type control within a vessel temperature over ranges from −100° to +650° F or 650° to 1000° F, with ¾" or 1" NPT thermowells. Accuracy is ±2°F. Bulletin TR-641.—*Instruments, Inc., Subs. of National Tank Co., Box 556, Tulsa, Okla.*

CIRCLE 374 ON READER-SERVICE CARD

DELAY MULTIVIBRATORS/ PULSE SHAPERS



New Model DM-30 Delay Multivibrator contains 3 independent monostable (one-shot) multivibrators capable of generating pulses in variety of widths, is useful in applications calling for delayed levels of pulse shaping and standardizing. New Model DM-30A Adjustable Delay Multivibrator also provides means of continuously varying or trimming pulse width, is useful in applications calling for precise pulse width control.—*Computer Control Co., Inc., 983 Concord St., Framingham, Mass.*

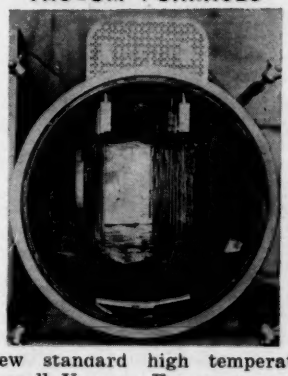
CIRCLE 375 ON READER-SERVICE CARD

DIGITAL LOGIC ELEMENT

New CTL-250 series of core-transistor Logic Elements operates to 250 kc. Available with either positive or negative input/output pulse polarity. Military versions obtainable on special order.—*DI/AN Controls, Inc., 944 Dorchester Ave., Boston 25, Mass.*

CIRCLE 376 ON READER-SERVICE CARD

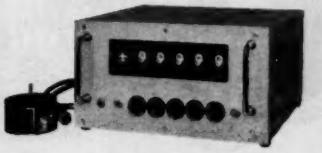
VACUUM FURNACES



New standard high temperature cold wall Vacuum Furnaces produce up to 2500°C at $1x10^{-5}$ mm Hg. Internally heated hot zones may be arranged vertically or horizontally; sizes range from 60 to 2,700 cu in.—*Vacuum Specialties, Inc., Geophysics Corp. of America, Bedford, Mass.*

CIRCLE 377 ON READER-SERVICE CARD

BI-DIRECTIONAL COUNTER



NEWEST IN NEW LINE OF ANALOG TO DIGITAL CONVERSION PRODUCTS FROM HYDRO-AIRE

This highly versatile, 45,000-count-per-second readout device indicates true position while going through zero in either direction. No need for external reset to establish reference, thus reducing the cost and complexity of related devices while simplifying system design and maximizing reliability. Modular construction of this compact, fully transistorized counter includes self-contained power supply and output connector.

When used with Hydro-Aire's Phototron transducer, this new counter converts inputs to Nixie tube visual readout and to digital type electrical readout for information storage, automatic machine control and process control systems—wherever precision numerical readout is required.

Detailed specifications on this and related products now available from Hydro-Aire are yours on request.

HYDRO-AIRE
DIVISION OF
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3000 WINONA AVE., BURBANK, CALIF.
Solid-state devices include time delay devices, voltage regulators, power supplies, inverters.

CIRCLE 153 ON READER-SERVICE CARD

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Division of Colorado Oil and Gas Corporation • Dept. 42, Skokie, Ill., Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta • Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas • Eastern Seaboard Warehouse: Marsh Instrument Company, 1209 Anderson Ave., Fort Lee, N. J.

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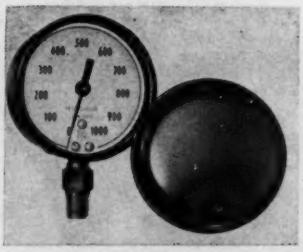
GAUGES • THERMOMETERS
VALVES

CIRCLE 154 ON READER-SERVICE CARD

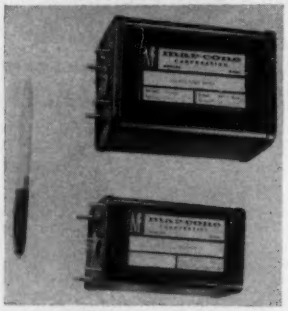
POCKET TEST GAGE



New Ashcroft Pocket Test Gages include compound ranges and rugged new optional friction-fit protective cover. Compound ranges are from 30 psi & 30" through 300 psi & 30". Pressure ranges are from 0-30 psi through 0-1000 psi.—Bulletin 363.—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*

CIRCLE 378 ON READER-SERVICE CARD

POWER SUPPLIES



New 9160 Series (2⅜" x 2¼" x 4") and 9360 Series (3$\frac{1}{16}$" x 2$\frac{1}{16}$" x 4") low cost, plug-in, transistorized power supplies provide better than 0.01% voltage regulation for line variations of 100 to 130 v, and 0.3% load regulation. Outputs of 12, 18, and 24 v with output currents from 400 to 200 ma (Model 9160) and 1.2 to 0.600 amps for (Model 9360).—*Mar-Cone Corp., 51 Kenneth St., Newton Highlands 61, Mass.*

CIRCLE 379 ON READER-SERVICE CARD

POWER SUPPLY

New Power Supply, "first commercially available supply for thermoelectric cooling modules," is intended for low-power lab experimentation. Output current to 20 amp is manually adjustable, monitored by front panel meters; maximum power output is 50 w.—*Mar-Cone Corp., 51 Kenneth St., Newton Highlands 61, Mass.*

CIRCLE 380 ON READER-SERVICE CARD

THE EQUIPHASE* TRIPLE-POINT-OF-WATER CELL

a convenient standard for establishing a fixed temperature reference point.

EQUIPHASE Triple-Point-of-Water Cell establishes a reference temperature of 0.01°C with guaranteed accuracy of 0.0005°C. Unaffected by atmospheric pressure, contamination-free, easy and convenient to use. Just 17" high, 8" diameter.

This new laboratory standard establishes the precise point, 0.01°C, where ice, water, and water vapor coexist in equilibrium. The reference temperature point produced by the Equiphase Cell is accurate within 0.0005°C and may be quickly established with a minimum of technique or set-up.

The Equiphase Cell's accuracy cannot be easily duplicated with an ice bath. The triple-point-of-water is a physical constant — so precisely reproducible that it has been recently designated as a defining fixed point for the International Practical Temperature Scale of 1948 by the General Conference on Weights and Measures.

Reliability? Ease of use? Reasonable price? You get all these as well. But even more important — if you must have accuracy, this must be your standard.

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TRANS-SONICS, INC.
BURLINGTON, MASSACHUSETTS

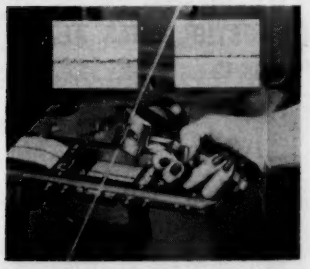
CIRCLE 155 ON READER-SERVICE CARD

ELECTRONIC TIMER

New HC-100 Vacuum Tube Electronic Timer for industrial control purposes offers precise time adjustments infinitely variable over entire range. SPDT plug-in relay output rated at 5 amps, timing ranges from 0.06 to 120 sec, repetitive accuracy of ±2%.—*Syracuse Electronics Corp., Box* 566, *Syracuse* 1, *N. Y.*

CIRCLE 381 ON READER-SERVICE CARD

TENSION RECORDER



New Electronic Tension Recorder shows quickly changing tensions electrically during preparation of wires and cables at full speed. Unit operates at 5 and at 50 mm/sec. Thousandths-of-a-second registration is indicated by separate time-markings (above tension graphs). Tension is sensed by a hand-held Electric Tension Transducer; large transducers extend use of Recorder for tensions of moving tirecords, control cables, etc. —*Tensitron, Inc., Box* 185, *Harvard, Mass.*

CIRCLE 382 ON READER-SERVICE CARD

STATISTICAL SHOCK RECORDER

New unidirectional, four-channel Statistical Shock Recorder Model 3R-4 features accuracy of ±5%, frequency response 0-40 cps (min.), no power requirements. Conforms to MIL E-5272.—*Inertia Switch Inc.,* 311 *W. 43rd St., New York* 36, *N. Y.*

CIRCLE 383 ON READER-SERVICE CARD

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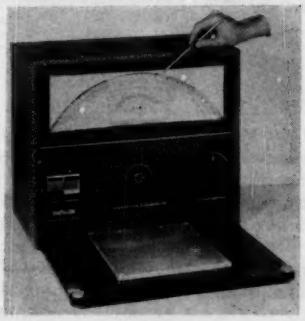
CIRCLE 156 ON READER-SERVICE CARD

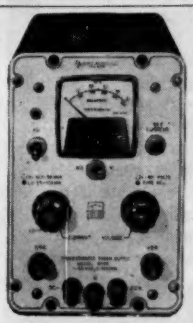
ABSORPTION DYNAMOMETER



New 1200 Series Absorption Dynamometer features special hysteresis brake to reduce starting torque and to improve high-speed performance, and automatic transfer of torque ranges through progressive spring loading system. Photoelectric tachometer eliminates mechanical contact between shaft and transducer. Unit is accurate within 1%, can apply clockwise and counter-clockwise torques without set-up changes.—*John Chatillon & Sons,* 85 *Cliff St., New York* 38, *N. Y.*

CIRCLE 186 ON READER-SERVICE CARD

For More Information
Circle Reader-Service Card.



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MODEL 4005

AMBITROL V-P™

CONSTANT | VOLTAGE / CURRENT

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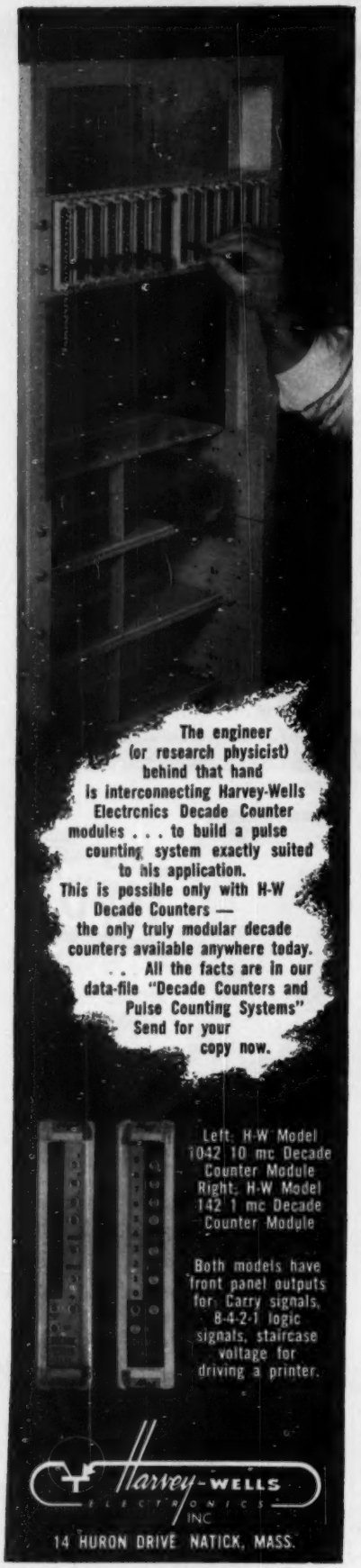
F.O.B. FACTORY
Write For Catalog

0-40 volt, 500 ma, regulated DC power supply featuring AMBITROL, a transistorized regulator providing continuous control of voltage or current to .05%.

*S P D T : Silicon Planar Diffused Transistor High Stability Amplifier

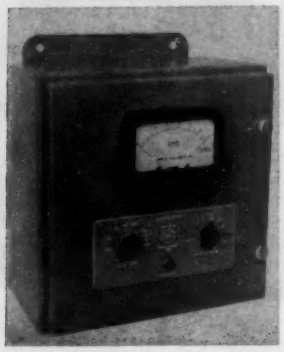
Power Designs inc.
1700 SHAMES DRIVE
WESTBURY, L. I., N. Y.
EDgewood 3-6200 Area Code 516

CIRCLE 123 ON READER-SERVICE CARD



CIRCLE 158 ON READER-SERVICE CARD

CONDUCTIVITY METER



New Model RA-3 Conductivity Meter is calibrated directly in weight percentage NaOH from 0 to 7%, can be supplied with automatic or manual temperature compensation from 110° to 200°F. Cell selector switch permits use of single caustic meter with number of conductivity cells installed at different locations.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, Essex Co., N. J.*

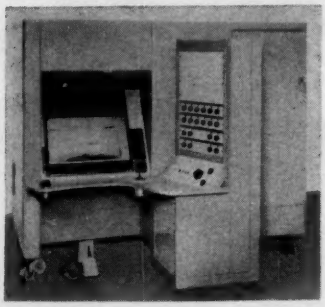
CIRCLE 384 ON READER-SERVICE CARD

NUMERIC INTERROGATOR

New Model 2501 Numeric Interrogator "makes point-of-use automatic data processing possible for the first time." Unit requests information, adds new information to data processing file, up-dates, modifies or deletes stored information, adds new information to received message and then re-transmits all or part of new message. Any 6 or 7 bit binary code can be used; bit rate up to 1 Mc; character transmission rate to 10,000 characters/sec.—*Information Products Corp., 156 Sixth St., Cambridge, Mass.*

CIRCLE 385 ON READER-SERVICE CARD

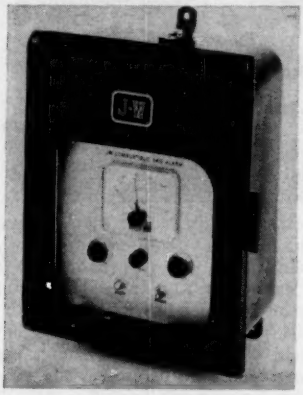
PRECISION FILM READER



New Film Reader makes photographs of nuclear tracks in bubble chambers or precise measurements of coordinates of lines or points from astronomy and satellite or missile tracking. Measurements are initially read into buffer storage from which they can be transferred to punched cards or perforated tape.—*Itek Labs., Div. Itek Corp., 10 Maguire Rd., Lexington 73, Mass.*

CIRCLE 386 ON READER-SERVICE CARD

COMBUSTIBLE GAS ALARM



New Model RH diffusion-head type alarm for continuous monitoring of hazardous gases and vapors has analyzer unit housed in dust-proof case; indicating meter, lamps and operating controls displayed through glass window in door; head containing detector filament connects to analyzer by means of three wires in ½" conduit. Flame arrestor screen allows atmosphere to reach filament but prevents ignition of explosive fumes.—*Johnson-Williams, Inc., Palo Alto, Calif.*

CIRCLE 387 ON READER-SERVICE CARD

LOGIC MODULE

New Model 220 is a one-megacycle, triple-inverter Logic Module for gating and strobing as well as for inverting pulses and levels. Three independent inverter stages can be connected in series, parallel, or series-parallel. Pulse requirements are 4.0 v amplitude and 4.0 μsec width.—*Harvey-Wells Electronics, Inc., 14 Huron Dr., Natick, Mass.*

CIRCLE 388 ON READER-SERVICE CARD

CARD READER

New automatic Recirculating Card Programmer can treat any three cards in sequence as a single unit of instructions, and is capable of re-reading these cards without scanning through the entire deck. Read cards are returned immediately to a hopper in sequence and ready for feeding again. Cards are scanned at the rate of 120/min, a relatively slow speed for certain kinds of programming.—*International Business Machines Corp., Data Processing Div.*, 112 *East Post Rd., White Plains, N. Y.*

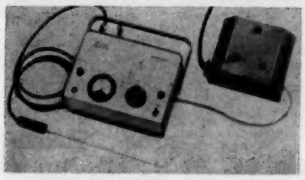
CIRCLE 389 ON READER-SERVICE CARD

UNIVERSAL RATIO SET

New 4393 Six-Dial Universal Ratio Set calibrates such instruments as the L&N 7553 Type K-3 Potentiometer and the 4232-B Wheatstone Bridge, and is used also for the precise calibration of resistance standards and odd-valued resistors, in resistor manufacturing as well as in standardizing laboratories. Total resistance is 2111.1 ohms. Limit of error at 25°C is 0.002% for dial changes of 100 ohms or more.—*Leeds & Northrup Co.*, 4934 *Stenton Ave., Phila.* 44, *Pa.*

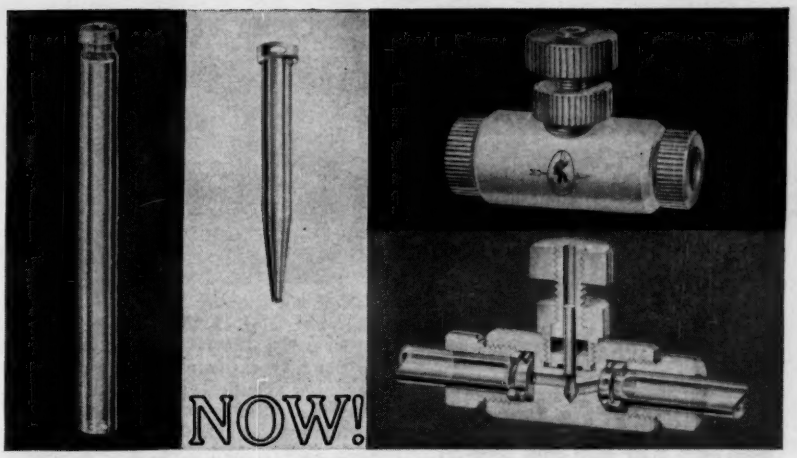
CIRCLE 390 ON READER-SERVICE CARD

RESISTANCE THERMOMETER



New Electronic Resistance Thermometer gives direct digital reading of temperature from −100° C to +900°C, with 0.25°C or 0.1% accuracy. Bulbs have vacuum-sealed platinum elements and leads, and hermetically sealed heads, with stainless steel or quartz jackets.—*Manostat Corp.*, 26 *N. Moore St., New York* 13, *N. Y.*

CIRCLE 391 ON READER-SERVICE CARD



Teflon* Needle Valves** with Rubber "O" Rings control flow of corrosive fluids—even under high vacuum!

At last, a needle valve that solves the problem of delicate control of flow of highly corrosive fluids, even under high vacuum! No chance of breakage or contamination—fluids touch only acid-and-alkali-resistant glass, teflon, and diamonite***!

Developed by the Manostat Corporation, this new needle valve incorporates 4 important improvements over previously available valves.

1 All plastic parts not in contact with fluid are made from highly corrosion resistant polypropylene that will withstand autoclaving temperatures.

2 Rubber "O" rings, situated so as not to come in contact with the fluid, assure high vacuum seals from the surroundings.

3 Connecting tubes are of heavy wall pyrex brand glass for added mechanical strength.

4 Needle is a sintered synthetic ruby—diamonite—stronger and more corrosion resistant than glass, especially against strong alkali.

PRICE LIST

Cat. No. G10428T—Teflon Needle Valve ready for use with directions but no glass parts. 6.95

Cat. No. G10428A—Glass connecting tube. ..... .55

Cat. No. G3118C—Buret tip..70

*Trade name for DuPont Polytetrafluorethylene

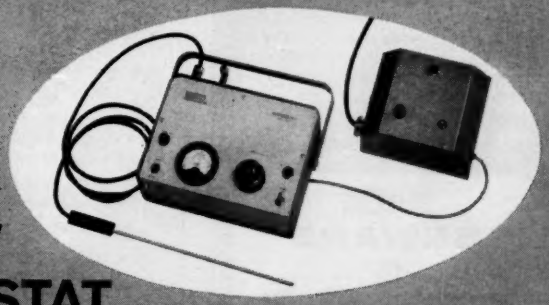
**Patent applied for ***Trade name for sintered corundum

The EMIL GREINER Co.

Dept. 423, 20-26 N. Moore St. N. Y. 13, N. Y.

CIRCLE 159 ON READER-SERVICE CARD

Outstanding precision... dependable time and work saver... new low price!



MANOSTAT
Electronic Resistance Thermometer

Direct temperature reading from −100°C to 900°C with 0.25°C accuracy!

Newly perfected design! Gives direct digital reading of temperature, from minus 100°C to plus 900°C, with an unusually high degree of accuracy: 0.25°C or 0.2% (whichever is greater). Eliminates the time-consuming calculations normally necessitated with high precision resistance thermometry. Each resistance bulb and bridge individually calibrated. Vacuum sealed platinum elements and leads in resistance bulb... hermetically sealed head... choice of stainless steel or quartz jacket. Plug-in controller accessory with 0.2°C reproducibility.

RT 1000 Electronic Resistance Thermometer individually calibrated but without Bulb or Controller **$975.00**

RT 1100 Stainless Steel Bulb, only **385.00**

RT 1200 Quartz Bulb, only.... **385.00**

RT 1300 Temperature Controller, only **112.50**

See your local laboratory supply dealer.

MANOSTAT Corporation

26 N. Moore St., New York 13, N.Y.

CIRCLE 160 ON READER-SERVICE CARD

At Last...

A CAPACITANCE PROBE LEVEL CONTROLLER COMBINING:

- *Amazing Stability*
- *High Sensitivity*

THE NEW *Fielden* **TEKTOR®**

World's Most Advanced Level Controller

Others think of long term drift in terms of hours...the new Fielden TEKTOR, after months or even years of service, holds drift to 2μf maximum. Revolutionary in design and construction, the new Fielden TEKTOR offers a combination of advanced features never before available in a capacitance probe instrument.

Send today for illustrated brochure with full specifications.

BUYERS BEWARE OF MISREPRESENTATION

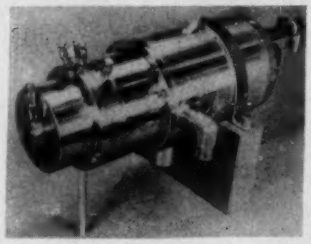
Do not be misled by company or independent sales representatives who may be selling level equipment under the guise that it is made by Fielden. The New TEKTOR®, TELSTOR® and PNEUTRONIC® level instruments, incorporating advanced design features, can ONLY be obtained from FIELDEN ELECTRONICS, INC., HUNTINGTON, LONG ISLAND, NEW YORK or through our representatives carrying authorized credentials.

Write or call for the name of your authorized representative.

Fielden
ELECTRONICS, INC.
HUNTINGTON, NEW YORK
Telephone (516) MYrtle 2-6045

CIRCLE 161 ON READER-SERVICE CARD

PLASMA GENERATOR



New 300-kw Arc Plasma Generator has electrodes of tungsten or copper with a 2% thoriated tungsten used as the rear cathode emitter, and copper used for the front anode. Operation is possible on monatomic and diatomic gases and gas compounds such as air, hydrogen, and nitrogen as well as the noble gases. Subsonic and supersonic assembly attachments are available.—*Plasmadyne Corp., Subs. Giannini Scientific Corp., 3839 S. Main St., Santa Ana, Calif.*

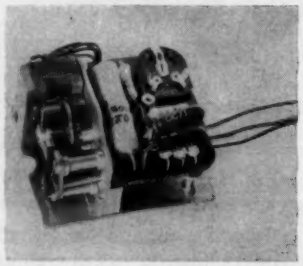
CIRCLE 392 ON READER-SERVICE CARD

RETICLE ADAPTER

New device for visual calibration of vibration equipment over a 30 cps to 200 cps range has two different reticle patterns engraved on the adapters. One, the CRL Wedge, provides measurement of 20, 40, 60 and 100 mils double amplitude; the other, the CRL Para-Line, is a series of parallel lines spaced 0.0647" apart to measure ±10 g at 55 cps, a requirement of many MIL specs.—*Columbia Research Labs., MacDade Blvd., & Bullens Lane, Woodlyn, Pa.*

CIRCLE 393 ON READER-SERVICE CARD

PULSER



New Model E59 Regulated Transistor Pulser is balance-wheel regulated with accuracy of 2.5 sec/24 hr of operation. E59 may be offered for any pulse repetition rate from 4 to 10 pps and for battery operaton from 1.5-12 v; pulse output is typically square wave +6 v, 5 msec on, 95 msec off for 10 pps.—*Presin Co., Inc., 2014 Broadway, Santa Monica, Calif.*

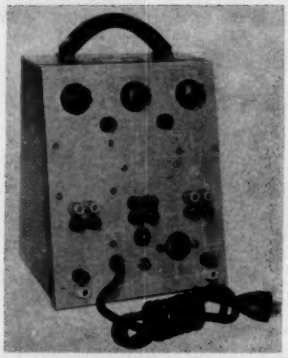
CIRCLE 394 ON READER-SERVICE CARD

HI-TEMP PRESS TRANSDUCER

New P732 Series of high-temperature gage- and differential-pressure Transducers have pressure ranges from 0-2 psi through 0-5000 psi on gage and uni-directional differential models and from ±1 psi through ±100 psi for the bi-directional differential model. Features include good temperature stability through unbonded strain gage, high overload characteristics, low sensitivity to static and vibratory accelerations, and combined non-linearity and hysteresis of less than ±0.75 in both high and low pressure ranges.—*Statham Instruments, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 395 ON READER-SERVICE CARD

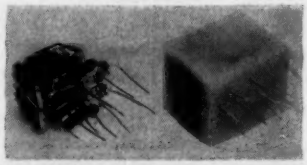
DECADE LINE CORRECTOR



New Decade Line Corrector, Type DLC1005, consists of three powerstat variable transformers individually connected to three buck-boost fixed-ratio transformers. Input rating is 125 v max, 50/60 cps, single phase. When used as a line corrector, the output rating is input voltage ±10%, 5.0 amp. Data Sheet SE-L126011.—*Superior Electric Co., Dept. DLC, Bristol, Conn.*

CIRCLE 396 ON READER-SERVICE CARD

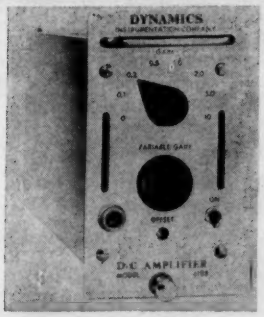
FLIP-FLOP



New DM 200 Flip-Flop, is a (200-kc) digital circuit module with two five-input AND gates plus transient coupling which allows the circuit to function as a shift register stage, counting stage, static storage, or perform other logic and control functions. Meets MIL-E-527D (ASG).—*Delco Radio Div., General Motors Corp., East Firmin, Kokomo, Ind.*

CIRCLE 397 ON READER-SERVICE CARD

GALVANOMETER AMPLIFIER



New chopper-stabilized, all-transistor D-C Amplifier, Model 4155, has ±100-ma, ±10-v output for driving high-frequency galvanometers. Has voltage gain steps from 0.1 to 10.0 (continuously variable between steps), an input impedance of 100 k (constant over the passband), frequency response of dc to 30 kc, and d-c drift of less than ±0.1% for any gain setting.—*Dynamics Instrumentation Co., 583 Monterey Pass Rd., Monterey Park, Calif.*

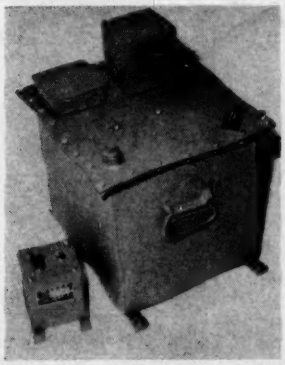
CIRCLE 398 ON READER-SERVICE CARD

DIGITAL COMPUTER SIMULATOR

New Model 2032 Memory System Exerciser, an automatic, high speed digital computer simulator, tests and evaluates complete memory systems, simulates exact computer environment for testing during development, prototype and production stages of coincident-current and word organized core, twistor, rod, multi-apertured and thin film memories. Accommodates random access memories or serial buffers with address capacities to 16,384 words and word lengths to 48 bits, permits rapid change-over between binary or binary-coded decimal address logic.—*Rese Engineering, Inc., A and Courtland Sts., Phila. 20, Pa.*

CIRCLE 399 ON READER-SERVICE CARD

HI VOLT POWER UNIT



New Model PU15-25, a 15,000-vdc Power Unit, features selenium rectifiers and a high-efficiency conversion circuit to insure low input-power requirements. Rated at 25 ma dc.—*Peschel Electronics, Inc., Towners, Patterson, N. Y.*

CIRCLE 400 ON READER-SERVICE CARD

ROTRON WHIRL-FLO *FLOWMETERS*

A wide range of dependable flowmeters designed on the Vortex-Velocity principle to provide an economical means of accurately measuring liquid or gas flow for the chemical, oil and gas industries.

MAIN FEATURES

- High Accuracy
- Direct totalization
- Versatility of readout...direct readout of flow rate at meter or transmission to remote locations ...automatic batch control available plus ticket printing and recording
- High capacity
- Economy...low installation cost...inherently larger capacity compared with other flowmeters size for size
- Simple construction facilitates field service
- Compact, simple design permits easy installation
- Rugged construction assures reliable, long life service
- Wide range of applications for liquids or gases...handles viscous fluids...even liquids with suspended solids

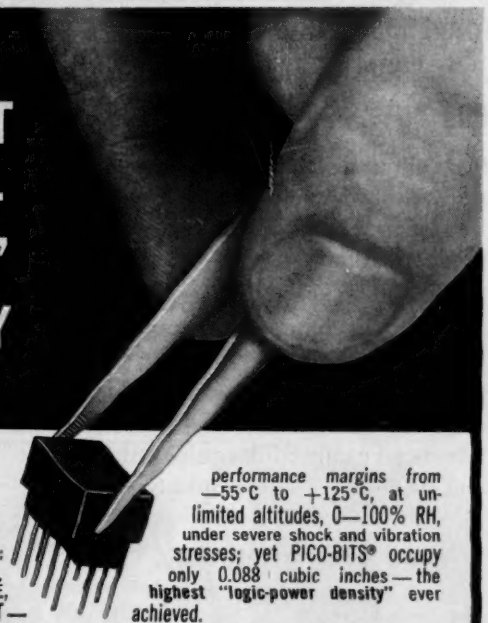
GENERAL SPECIFICATIONS

Pressure Rating: 2-inch meters 1500 psig or 5000 psig; 3-inch meters and larger 2000 psig.
Pressure Drop: for liquids less than 7 psig at max. flow; for gases usually less than 100 inches water at max. flow rate.
Sizes: models available from 2-inch to 16-inch for liquids or gases.
Accuracy: depends upon meter size; usually ±0.5% or better over 10:1 span. Repeatability better than ±.2%.
Standard Materials of Construction: 2-inch meter stainless steel; other sizes carbon steel; other materials available.
Capacity: liquid capacities range from 10 to 100 gpm for the 2-inch meter to 1400-21,000 gpm for the 16-inch meter; typical gas capacities range from 100-1000 scfm at 100 psi in a 2-inch meter up to 20-150 mmscfd in a 16-inch meter at 100 psi.

ROTRON® *write for full details*
ROTRON CONTROLS
division of
ROTRON MFG. CO., INC.
Bearsville Road, Woodstock, N. Y.

CIRCLE 162 ON READER-SERVICE CARD

HIGHEST "LOGIC-POWER" DENSITY



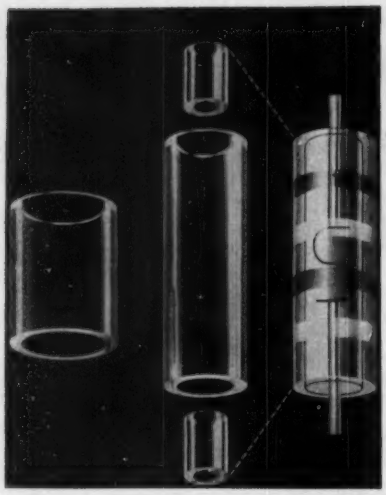
PICO-BITS® are micro-micro packages of our time-and-space-proven magnetic logic circuitry. A single PICO-BIT® can perform any basic logical function: AND, OR, INHIBIT, (AND NOT), BRANCH, STORE, TRANSFER, DRIVE, BINARY COUNT, or COMPLEMENT—greatly simplifying circuitry, minimizing semiconductors.

Magnetic logic provides the **lowest power dissipation per bit manipulated.** PICO-BITS® maintain full performance margins from —55°C to +125°C, at unlimited altitudes, 0—100% RH, under severe shock and vibration stresses; yet PICO-BITS® occupy only 0.088 cubic inches—the **highest "logic-power density"** ever achieved.

Literature on the DI-AN logic-element family is detailed, educational, stimulating, free. Write. Better still, telephone—we solve digital problems with elegance and dispatch.

di an® **DI/AN CONTROLS, INC.**
944 Dorchester Avenue • Boston 25, Mass. • Avenue 8-7700
magnetic digital/analog systems and components

CIRCLE 163 ON READER-SERVICE CARD



glass for your diode packages... precision drawn to specifications

— GARNER provides tighter tolerances . . . improved roundness and concentricity . . . squarer and smoother end cuts.

Parts ultrasonically scrubbed, chemically cleaned, and rinsed in deionized water. Shipped ready for your production line.

Meeting your specifications is insured by continuous inspection, starting with raw material.

Fast dependable deliveries based on large stocks of redraw tubing . . . advanced production equipment, and the ability to move quickly.

Send for complete data.

T. H. GARNER CO.

Serving the semi-conductor industry since 1954

177 S. INDIAN HILL BLVD.
CLAREMONT, CALIF. • NA*tional* 6-3526

CIRCLE 164 ON READER-SERVICE CARD

VT AMPLIFIER

New Type 114 is a vacuum-tube, chopper-stabilized Amplifier, designed to operate with Rustrak recorders. Particularly suited for output of low-voltage thermocouples; photo-electric devices; and other transducers with outputs in the low millivolts. Input impedance is 100,000 ohms, sensitivity is 9 mv full scale, drift and linearity are better than ½%.—*Rustrak Instrument Co., 130 Silver St., Manchester, N. H.*

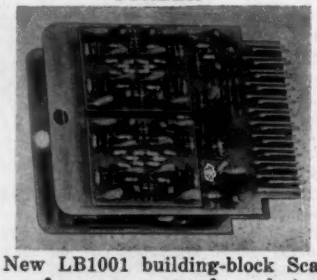
CIRCLE 401 ON READER-SERVICE CARD

IMPEDANCE BRIDGE

New Model 170A Universal Impedance Bridge measures the capacitance and dissipation factor of capacitors, the inductance and storage factor of inductors, and the a-c and d-c resistance of resistors. Resistance accuracy is ±(0.1% + 1 dial division); capacitance accuracy: ±(0.2% + 1 dial division); Inductance accuracy: ±(0.3% + 1 dial division).—*John Fluke Mfg. Co., Inc., Mountlake Terrace, Wash.*

CIRCLE 402 ON READER-SERVICE CARD

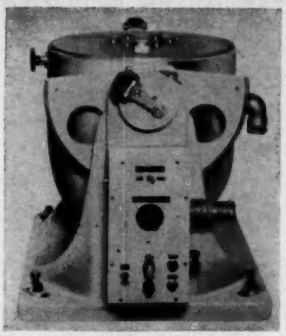
SCALER



New LB1001 building-block Scaler has a frequency range from dc to 1.5 Mc. Uses silicon Mesa transistors. Diode logic is used instead of NOR logic.—*Frontier Electronics Co., 4600 Memphis Ave., Cleveland 9, Ohio.*

CIRCLE 403 ON READER-SERVICE CARD

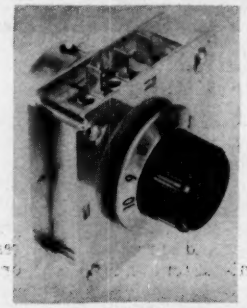
TUMBLE RATE TEST STAND



New CO5 6452 008 Tumble Rate Test Stand, which tests gyros and other devices requiring precise orientation or rotation, features rotary table locking arrangement; tapered roller bearings; 30 heavy-duty, low-noise slip rings; etc.—*Kearfott Div., General Precision, Inc., 1150 McBride Ave., Little Falls, N. J.*

CIRCLE 404 ON READER-SERVICE CARD

ADJUSTABLE TIMERS



New Series-41500 Timers are manually adjustable for intervals of from 5 sec to 5 hrs. Timers include a precision snap-action SPDT switch and require only 2.5 w for operation. Accuracy is ±1.6%.—*A. W. Haydon Co., Waterbury, Conn.*

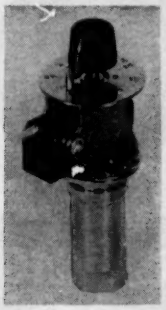
CIRCLE 405 ON READER-SERVICE CARD

TEMPERATURE RECORDER

New Temperature Recorder operates on a pyrometer principle utilizing the output from a thermocouple junction through a temperature compensator to cause deflection of a very sensitive galvanometer. No amplification is used. A six-foot thermocouple is connected to the rear terminals of the recorder directly. Five ranges from 0-500° F to 0-2500° F available. Accuracy: 2%.—*Rustrak Instrument Co., 310 Silver St., Manchester, N. H.*

CIRCLE 406 ON READER-SERVICE CARD

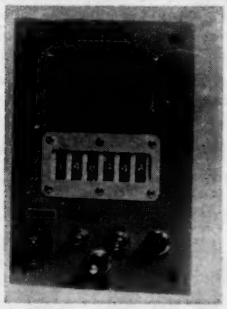
PRESSURE-VACUUM CONTROL



New calibrated Pressure-Vacuum Controller, Model H41, has several adjustable ranges from 30" Hg vac to 500 psi, with on-off differentials from 6 ±1" WC and up. Switch actions include NO, NC, and DT.—*United Electric Controls Co., Dept. X, 85 School St., Watertown, 72, Mass.*

CIRCLE 407 ON READER-SERVICE CARD

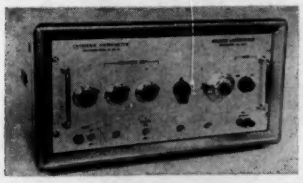
PREDETERMINING COUNTERS



New line of electric Predetermining Counters, Series 1801, registers up to 1500 counts/min. Reset time is 150 msec. Model P-1801 (illustrated) is for original equipment manfacturers, Model A-1801 (with a single row of preset dials) and Model B-1801 are for existing-equipment users.—*Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.*

CIRCLE 408 ON READER-SERVICE CARD

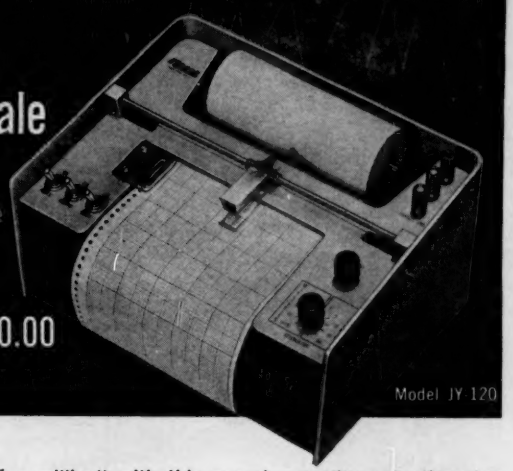
CRYOGENIC THERMOMETER



New electronic Cryogenic Thermometer, the Cryotherm, measures temperatures in range 0.3° to 25°K. Ruby-crystal probes fitting into test Dewars measure mutual inductances as small as 2 x 10^{-4} μh using an a-c bridge circuit. Operates from a-c bridge current supplied by a modular plug-in signal generator tuned to 155 cycles. Output from the bridge is amplified by transistorized amplifier.—*Malaker Laboratories, Inc., Mountainside, N. J.*

CIRCLE 409 ON READER-SERVICE CARD

NEW *Nesco*
GRAPHIC RECORDER
• 1 MV full scale
• maximum signal source resistance: 50 K ohms
Recorder prices start at $320.00



You can measure 1/100th of a millivolt with this superior quality potentiometer recorder. Unit is extremely accurate (½% of span), and fast (½ second balance time). Step selection of ranges up to 10 V is provided by attenuator on front panel.

Standard features include a floating input with separate chassis ground . . . 5" chart width . . . hum suppressor . . . chopper stabilization . . . changeable chart speeds. Write for Bulletin.

10 MV fixed span	$320.00	Model JY-100
10 MV to 100 V	$395.00	Model JY-110
1 MV full scale	$535.00	Model JY-120

Nesco
Manufacturers of Precision Recording Instruments
638 West 17th St., Costa Mesa, Calif.

CIRCLE 165 ON READER-SERVICE CARD

TANK-O-METER
FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

TANK MAY BE BURIED, ELEVATED, OPEN, CLOSED, VENTED OR UNDER PRESSURE OR VACUUM

SEND FOR BULLETINS

Also gauges for:
Barometric Pressure (Mercury Column)
Absolute Pressure (Mercury Column)
Pressure and Vacuum
Differential Pressure
Inclined Manometers for draft, pressure or differential pressure.

UEHLING INSTRUMENT CO. 470 GETTY AVE., PATERSON, N. J.

CIRCLE 166 ON READER-SERVICE CARD

FIRST AND ONLY
RECORDING pH METER

Permanent pH Record • Simple to Operate • Adaptable • No Ink

A pH meter and strip chart recorder in one. Line operated. Continuously indicating. Can record continuously for 31 days at one inch per hour. With manual temperature compensator. Write for Bulletin No. 3R.

Price $245.00 complete, with Analytical protected pH probe unit

ANALYTICAL MEASUREMENTS, INC.
585 Main Street
Chatham, New Jersey

CIRCLE 167 ON READER-SERVICE CARD

NOW YOU CAN BUY

OFF THE SHELF! FOR IMMEDIATE SHIPMENT*

transmitters (1HG, 1HG400, 5HG, 5HG400)
. . . angle transmission units for torque transmission and servo control systems.

receivers (1F, 1F400, 5F, 5F400)
. . . used as receivers in torque transmission systems. Have shaft damping to prevent oscillation and overcome any tendency to spin.

control transformers (1HCT)
. . . produce an a-c voltage at the rotor terminals that depends on rotor shaft position and the voltages applied to windings.

differential transmitters (1HDG, 5HDG)
. . . "add in" other shaft positions when connected between transmitter and receiver or control transformer.

Use Telesyn synchros for extremely accurate drives and indicators of position, pressure, flow or other synchro-transmitted information.

A pioneer in the field of synchronous transmissions, Ford Instrument Company produces synchros of proven precision.

- Available to meet MIL specs.
- In sizes to meet a multiple of requirements.
- For torque transmission and voltage indication.

**Subject to prior sale. Ford inspection 7 days A.R.O.—Government inspection 12 days A.R.O.*

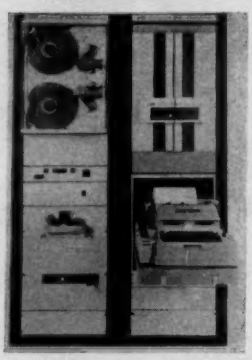
1.3

FORD INSTRUMENT COMPANY

Division of The Sperry Rand Corporation
31-10 Thomson Ave., Long Island City 1, N. Y.

CIRCLE 168 ON READER-SERVICE CARD

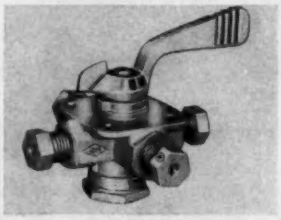
PERIPHERAL COMPUTER EQUIPMENT



New line of Peripheral Equipment for plug-in connection to the PB250 computer includes magnetic tape units, high-speed buffer, tape reader, tape punch, and line printers, card reader, digital graph recorder, analog-to-digital and digital-to-analog converters, etc. Catalog SP140.—*Packard Bell Computer, Subs. of Packard Bell Electronics, 1905 Armacost Ave., Los Angeles 25, Calif.*

CIRCLE 410 ON READER-SERVICE CARD

SAMPLING VALVE



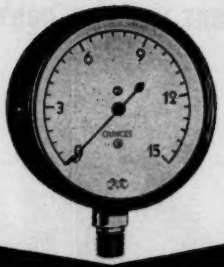
New Valve for measuring off and taking samples for analysis by gas chromatography features two designs, a 4-way, and a double 4-way (two 4-ways stacked), with port connections for unflared ⅛" tubing, 0-ring compression seal, and self-lubricating Teflon plug. Bulletin 461.—*Republic Mfg. Co., 15655 Brookpart Rd., Cleveland 35, Ohio.*

CIRCLE 411 ON READER-SERVICE CARD

ELECTRIC TYPEWRITER

New line of data processing components includes heavy-duty Electric Typewriter as an input-output device for systems. Features easily activated, sixteen-key, illuminated keyboard control and optional control from carriage position.—*Smith-Corona Marchant Inc., Data Processing Technical Sales, 410 Park Ave., New York, N. Y.*

CIRCLE 412 ON READER-SERVICE CARD



MARSHALLTOWN

DIAPHRAGM GAUGES

for accurate pressure measurement in ounces or inches of water

Standard dials reading in inches of water, ounces, centimeters or millimeters up to 10 P.S.I. All Marshalltown diaphragm gauges are extremely sensitive and accurately measures very low pressures.

Let Marshalltown answer your gauge problems . . . write for information and prices.

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CIRCLE 169 ON READER-SERVICE CARD

MICO

Heavy-Duty 2 & 3 Dimensional Engraver

FOR:
Engraving Nameplates
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Profiling Small Objects
Making Small Dies and Molds

FEATURES OF NEW ENGRAVER

1. Six Reduction Ratios—From 1.5:1 to 4:1.
2. Heavier bearings in micrometer spindle.
3. New 1/10 H.P. Ball Bearing Motor permits continuous operation for die or mold work in steel.
4. Absolute accuracy for three-dimensional reproduction.
5. Uses standard taper-shank cutters or ⅛" diameter straight shank cutters and end mills.
6. Copy and work right-side-up: always in direct view of operator.
7. Many attachments available to increase versatility of machine.

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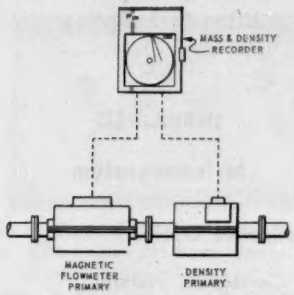
CIRCLE 170 ON READER-SERVICE CARD

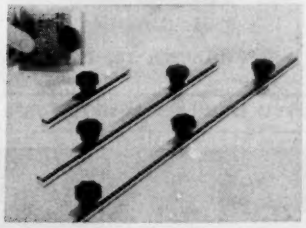
MASS FLOW



New Mass-flow Measurement System is obstructionless, and unaffected by viscosity, pressure, temperature, or piping configurations. Accuracy is up to ±1.5%. System has two primary elements: magnetic flowmeter which measures the volume flow rate, and radiation density detector. Signals are multiplied in a single secondary readout instrument which can be supplied as an intergrator, controller, pneumatic transmitter, or in a combination. Rangeability is to 3000:1; response is 2 to 3 sec for full scale step input.—*Fischer & Porter Co., 792 Jacksonville Rd., Warminster, Pa.*

CIRCLE 413 ON READER-SERVICE CARD

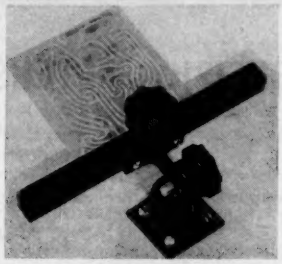
SOLDER MASK



New Quick-Clip Solder Mask fits snugly over etched connector contacts on printed-circuit boards to prevent adherence of solder during the dip-soldering. Made of aluminum with sprayed Teflon coating on surfaces, mask can be cleaned in any commonly used organic solvents without damage. —*Western Electronic Products Co., 2420 N. Lake Ave., Altadena, Calif.*

CIRCLE 414 ON READER-SERVICE CARD

PRINTED-CIRCUIT VISE

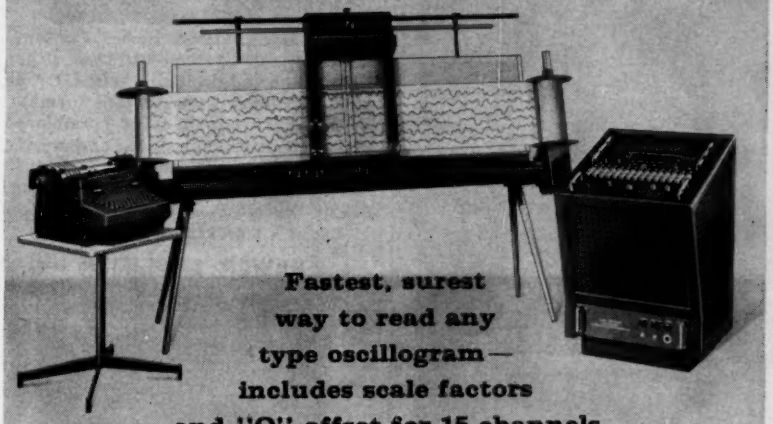


New Quick-Clip Vise holds printed-circuit boards during assembly and hand-soldering, is 6" long with jaws 13/32" deep, of polished black anodized aluminum.—*Western Electronic Products Co., 2420 N. Lake Ave., Altadena, Calif.*

CIRCLE 415 ON READER-SERVICE CARD

GSI

Analog-to-Digital Data Reduction System



Fastest, surest way to read any type oscillogram— includes scale factors and "O" offset for 15 channels

YOU GET FACTS FASTER with Gerber's data-reduction systems . . . base decisions on up-to-the-minute information . . . free engineers from tedious clerical labor for the creative work they're being paid for.

For large areas, **Model S-10 Scanner** offers 16" x 66" backlighted surface (smaller scanner also available). Variable speeds from 0 to 100 fpm; instant braking; reversible. Projection system to handle 16-35-70 mm film is optional.

Newly redesigned reading head can read full width of 16" records and 20" along x axis. Variable scale is incorporated in reading head to handle frequency requirements.

Basic Control Console utilizes 4-digit voltmeter (0000 to ±9999) accurate to .01% to measure proportional voltages of either X, Y, or frequency potentiometers; value is displayed in projection lamp banks.

Outputs: IBM typewriter, card punch, punched paper tape, plotter, etc.

Modular construction, easily expanded for increased work load or new applications.

Write today for Bulletin GADRS-2 for the full details.

GSI

THE GERBER SCIENTIFIC INSTRUMENT CO.

140 VanBlock Avenue, Hartford 14, Conn.

CIRCLE 171 ON READER-SERVICE CARD

HERE'S THE FIRST SMALL COMPLETE DATA-ACQUISITION SYSTEM

The new low-cost Genisco APD Data Acquisition system is a complete and compact solid-state packaged system designed to meet a wide range of instrumentation requirements. You can use it to read out thermocouples, resistance thermometers, strain-gage transducers or any other DC voltage low-impedance sensors. Modular plug-in board design allows great flexibility—one chassis can provide a complete 20-channel system.

Data is sampled at 20 samples per second; repeatability is 0.1% of full scale. Output can be shown or recorded directly in engineering units with sign indication and channel identification. Readout can be converted to punch tape, magnetic tape, typewriter or other storage medium.

The new Genisco APD requires low power and is ideal for portable, laboratory, or field use. Call or write today for prices and complete details.

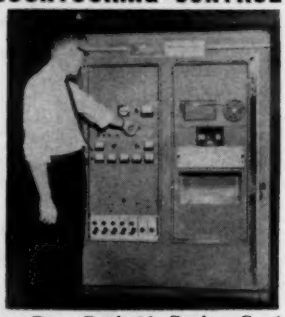
***Analog-to-Pulse Duration**
Patent Applied For

Genisco
INCORPORATED

2233 Federal Ave., Los Angeles 64, California

CIRCLE 172 ON READER-SERVICE CARD

COUNTOURING CONTROL



New DynaPath-20 Series Contouring Control System utilities either binary-coded-decimal (BCD) or straight binary punched-tape formats. With BCD format, it is possible to make, modify, reproduce, and verify tapes on a Flexowriter.—*Bendix Corp., Industrial Controls Section, 21820 Wyoming, Detroit 37, Mich.*

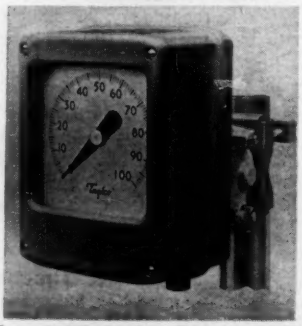
CIRCLE 416 ON READER-SERVICE CARD

POWER AMPLIFIER

New signal-generator Power Amplifier, Type 230-A, provides RF output power levels up to 4 w or +6 dbw (14 v rms into 50 ohms) with input from a conventional signal generator over the range from 10 to 500 Mc. Employs three tuned, cascaded stages of grounded grid amplification for minimum power gain of 34 db reproduces AM, FM, and pulse modulation characteristics with minimum distortion.—*Boonton Radio Corp., Boonton, N. J.*

CIRCLE 417 ON READER-SERVICE CARD

DP TRANSMITTER



New 212T Series Transcope Flow and Differential Pressure Transmitter features liquid-filled, diaphragm-sealed primary unit, cantilever springs to extract square root from flow measurement, calibration to give linear output proportional to differential pressure. Transmission accuracy ½% over continuously-adjustable range of 20" to 250" WC (differential pressure).—*Taylor Instrument Cos., 95 Ames St., Rochester 1, N. Y.*

CIRCLE 418 ON READER-SERVICE CARD

Ultra-fast Optics

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INFRA-RED

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Reflective Optics

Cassegrain Systems

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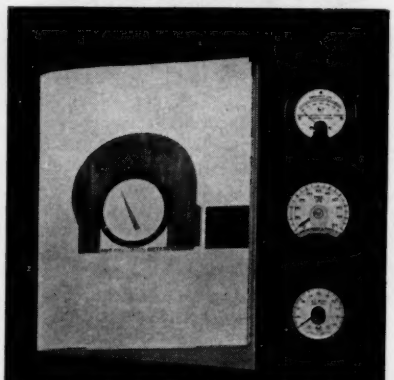
Mechanical Mountings

John Unertl Optical Co.

3551-55 East St.

Pittsburgh 14, Pa.

CIRCLE 173 ON READER-SERVICE CARD



AMF

PRECISION METERS

Catalog Available

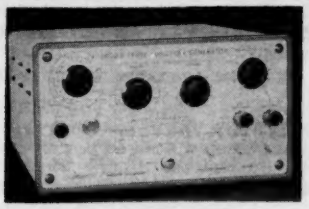
If your operation demands accuracy to 1/10 of 1% you need this AMF Catalog, which includes specifications, sizes and weights of Frequency and Volt Meters for test, research, industrial, military and government use. AMF Meters are rugged. They compensate for practically any temperature and environment. They can be tailored to your requirements—or are available immediately from stock. Send today for your Catalog! Address Department F

American Machine & Foundry Co.

1101 N. Royal Street, Alexandria, Virginia

CIRCLE 174 ON READER-SERVICE CARD

TRIPLE FUNCTION GENERATOR



New Model LRG 051 Triple Function Generator produces three synchronously initiated output waveforms: a positive 100-v sawtooth, a positive 10-v pulse, and a positive 10-v pulse delayable from 0 to 100% of the sawtooth duration. Both pulses are variable in amplitude, and length is determined by the sawtooth, which is continuously variable in decades from 100 sec to 10 μsec.—*Argonaut Associates, Inc., Box 273, Beaverton, Ore.*

CIRCLE 419 ON READER-SERVICE CARD

FILM VIEWER

New 16-mm Film Viewer, Model 6585, features motorized film drive, a remote operator control, and 20X magnification. Operator can traverse film in either direction at 120 cm/sec. Film speed can be varied continuously from 1.3 to 0 cm/sec. A film area of 14.5 mm x 35 mm is projected on the 27.5" x 11.5" viewscreen. Distortion is not more than ±1%. Bulletin 6585.—*Geotechnical Corp., 3401 Shiload Rd., Garland, Tex.*

CIRCLE 420 ON READER-SERVICE CARD

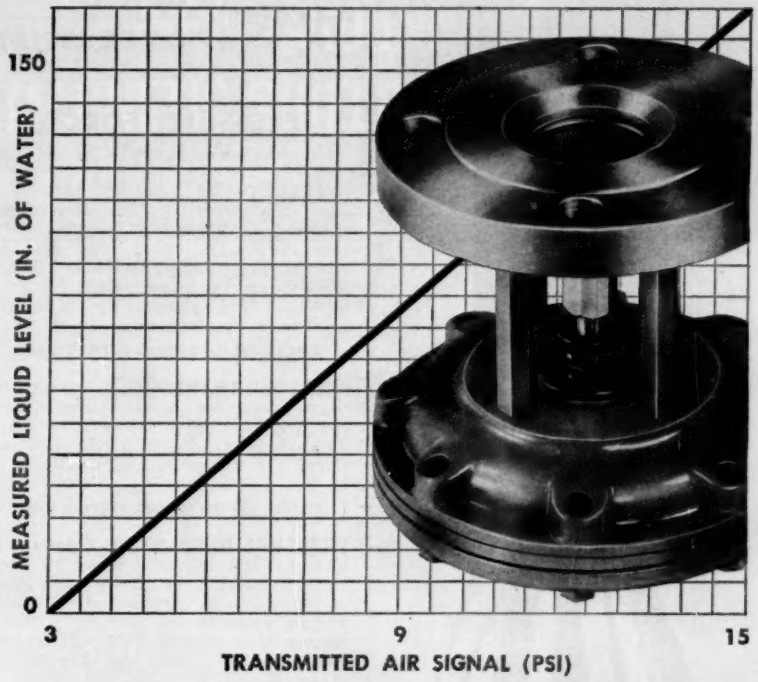
SAMPLE AND HOLD UNIT

New Sample-and-Hold Unit Model SH4 samples a one-microsecond segment of an incoming signal and holds the result for conversion to digital representation. Input frequency range is from dc to 100 kc and input impedance is 10 ±0.02% kilohms/v. Output voltage range is ±10 v.—*Packard Bell Computer, Subs. of Packard Bell Electronics, 1905 Armacost Ave., Los Angeles 25, Calif.*

CIRCLE 421 ON READER-SERVICE CARD

For More Information
Circle Corresponding Number
On Reader Service Card

TYPICAL PERFORMANCE CURVE OF MODEL "P" TRANSMITTER



LOW COST
PRESSURE AND LIQUID LEVEL TRANSMITTER
WITH
QUALITY
FEATURES
FOR
DEPENDABLE
OPERATION

The Conoflow Model "P" Transmitter is a low cost, rugged instrument which measures pressure and liquid level and transmits a *linear* 3-15 psi signal to standard receiver elements. Incorporates many features not found in more expensive devices for guaranteed dependable operation.

Safety—Process liquids and gases cannot back up into air lines and damage costly instruments. This is assured by the complete separation of measuring diaphragm from pneumatic pilot.

Simple Installation—The Model "P" can be mounted either horizontally or vertically on open or closed vessels. No dip tubes, floats or other mechanical devices are required inside the tank.

Long Life—Only the corrosion-resistant *Inconel X* diaphragm is exposed to the measured material. Preformed diaphragm will not work-harden or fatigue; withstands pressures to 500 psi and temperatures to 450°.

Versatile—Can be used for practically any service; ideal for viscous fluids or materials with solids in suspension; also for flowing bulk materials such as pigments, flakes, etc.

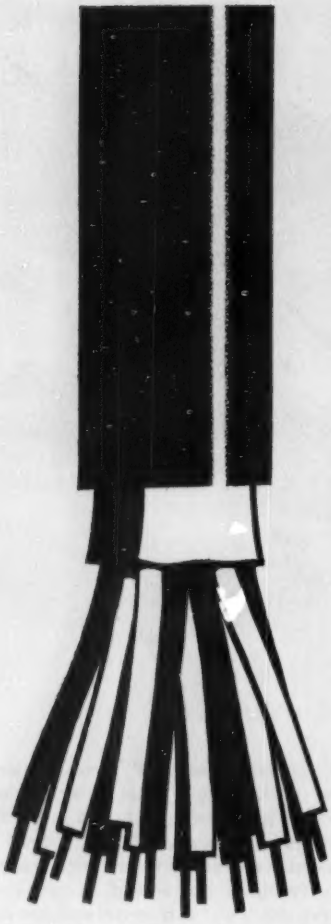
Choice of Ranges—Available for measuring ranges as low as 0 to 100" of water and pressures as high as 250 psi. Ranges can be changed in the field.

Specifications—New Bulletin P-36-1 contains complete specifications on the Conoflow Model "P" Transmitter. Write for your copy today or ask for a quote. No obligation. Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa.

CC-1003

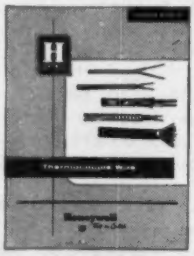
CONOFLOW CORPORATION
FOREMOST IN FINAL CONTROL ELEMENTS
SUBSIDIARY WALWORTH

CIRCLE 175 ON READER-SERVICE CARD



MULTIPLE-CONDUCTOR T/C EXTENSION CABLE

Available with from 4 to 48 pairs of solid-conductor temperature-compensated wires. Each wire is numbered, individual conductors are twisted into pairs, each pair is color-coded by wire type. No conduit needed. Supplied in custom and standard constructions. From this one dependable source come thousands of other accessories to help your instruments perform at their very best.



Get details from your Honeywell field engineer, or write today for Catalog G100-2.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

CIRCLE 176 ON READER-SERVICE CARD

NEW LITERATURE

PRESSURE, FORCE WEIGHT

PRESSURE GAGES in 3" and 5" dial sizes that maintain accuracy under extreme conditions of overload pressure, vibration, shock, etc. are described in 4-page Bulletin 280.—American-Standard Controls Div., Rochester Instrument Plant, 100 Rockwood St., Rochester 10, N. Y.

CIRCLE 422 ON READER-SERVICE CARD

PRESSURE TRANSDUCER. 8-page brochure describes 3S-G Silicon Semiconductor Strain Gage Pressure Transducer.—Fairchild Controls Corp., 119 Park Ave., Hicksville, L. I., N. Y.

CIRCLE 423 ON READER-SERVICE CARD

PRESSURE REGULATOR. 4-page Bulletin LC-100 describes Type 10 Pressure Regulator in which high-gains servomechanism permits use of downstream pressure for piloting, with accuracy of 1 part in 5000.—Lexington Controls, Inc., Box 132, Burlington, Mass.

CIRCLE 424 ON READER-SERVICE CARD

POTENTIOMETER TRANSDUCERS. 4-page Bulletin PT-1 describes pressure, motion, altitude, recording, etc. transducers.—H. E. Sostman & Co., 347 E. Lincoln Ave., Cranford, N. J.

CIRCLE 425 ON READER-SERVICE CARD

TRANSDUCER. 2-page Bulletin P-61206 presents features of Model 206 Teledyne Bonded Strain Gage Pressure Transducer; 8-page Service Manual contains instructions for its calibration and maintenance.—Taber Instrument Corp., 107 Goundry St., North Tonawanda, N. Y.

CIRCLE 426 ON READER-SERVICE CARD

TEMPERATURE

TEMP SENSING. 4-page Brochure ATL-903 includes 4 data sheets on surface, steel-in-wall, and aluminum-in-wall Delta-Couples.—Advanced Technology Labs., Div. American-Standard, 369 Whisman Rd., Mountain View, Calif.

CIRCLE 427 ON READER-SERVICE CARD

HEATING FURNACE CONTROLS. 24-page Folio 122 details automatic control for open hearth furnaces, glass tanks, reheating and annealing furnaces, and soaking pits; includes 50 photos and diagrams of installations.—GPE Controls, Inc., 240 E. Ontario St., Chicago 11, Ill.

CIRCLE 428 ON READER-SERVICE CARD

METAL-SHEATHED THERMOCOUPLES. 8-page Bulletin TT-317 illustrates and describes metal-sheathed thermocouples for applications requiring miniaturization, multi-point sensing, and hard-to-get-at installations.—Trinity Equipment Corp., Cortland, N. Y.

CIRCLE 429 ON READER-SERVICE CARD

TEMPERATURE REGULATOR, 8-page Catalog TCV-1 contains technical data on line of temperature regulators.—OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

CIRCLE 430 ON READER-SERVICE CARD

BUTTERFLY VALVES. 4-page Bulletin 6 describes new designs in rubber seat butterfly valves.—Henry Pratt Co., 319 W. Van Buren St., Chicago 7, Ill.

CIRCLE 431 ON READER-SERVICE CARD

HYDRAULIC CONTROL PILOT. No. 811, for accurate control of diaphragm valves is described in 2-page catalog sheet.—Atlas Valve Co., 280 South St., Newark 5, N. J.

CIRCLE 432 ON READER-SERVICE CARD

FLOW, PUMPS

FLOWMETER. 2-page Spec Sheet M22-6 describes operation of Solids Flow Meter for measurement of granular materials such as coal, ore, and crushed rock in vertical ducts, spouts, or pipes.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 433 ON READER-SERVICE CARD

ROTAMETER TRANSMITTER. Bulletin 18E describes application and operation of induction-type, solid-state transmitters for use with electric receivers or computers.—Schutte and Koerting Co., Dept. MA-3, Cornwells Hts., Bucks Co., Pa.

CIRCLE 434 ON READER-SERVICE CARD

FLOWMETER. 6-page Bulletin GEZ-3260 describes True Mass Flowmeter for jet-aircraft refueling.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 435 ON READER-SERVICE CARD

METERING PUMPS. 6-page Bulletin 91048 describes Measure-Matic* Pumps, adjustable and non-adjustable, for metering, injecting, sampling, feeding, etc.—Airmatic Valve, Inc., 7313 Associate Ave., Cleveland 9, Ohio.

CIRCLE 436 ON READER-SERVICE CARD

FLUID METERS for recording, indicating and integrating; transmitters and recorders for pressure and draft; level transmitters; and temperature instruments are described in 4-page Bulletin G14-1.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 437 ON READER-SERVICE CARD

FLOWMETER. 6-page Bulletin GEZ-3089 describes Type TJ-62 Mass Fuel Flowmeter for accurate fuel measurement requirements in aircraft applications where maximum fuel-flow rates exceed 15,000 pph.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 438 ON READER-SERVICE CARD

PROPORTIONING PUMP. 4-page Bulletin A10 describes proportioning pump designed for metering, sampling, treating and injecting applications.—Afton Engr. Co., Box 9426, Houston, Tex.

CIRCLE 439 ON READER-SERVICE CARD

FUEL PUMPS. 6-page Bulletin A-5242A describes fixed displacement vane-type fuel pumps.—Aero Hydraulics Div., Vickers Inc., Div. Sperry Rand Corp., Box 302, Detroit 32, Mich.

CIRCLE 440 ON READER-SERVICE CARD

CENTRIFUGAL PUMPS. 8-page Bulletin 301 gives performance curves and technical data on pumps for corrosive service.—Industrial Filter & Pump Mfg. Co., Dept. 300, 5900 Ogden Ave., Cicero 50, Ill.

CIRCLE 441 ON READER-SERVICE CARD

FLOW TUBE. 4-page Catalog 405 describes low-head-loss "Lo-Loss" Flow Tube.—Penn Meter Co., 4110 Haverford Ave., Phila. 4, Pa.

CIRCLE 442 ON READER-SERVICE CARD

VALVES

FLOW CONTROL VALVES. 12-page Bulletin 606 CV describes Series C Slurry Valves which have rubber inner liners that give fast, variable venturi control.—Clarkson Co., 735 Loma Verde Ave., Palo Alto, Calif.

CIRCLE 443 ON READER-SERVICE CARD

SURGE ARRESTOR VALVE. 16-page Bulletin W-16 describes Cushioned Surge Arrestor Valve that anticipates surge to protect system.—Golden-Anderson Valve Specialty Co., 1285 Ridge Ave., Pitstburgh 33, Pa.

CIRCLE 444 ON READER-SERVICE CARD

NEEDLE VALVES. 4-page Circular 568 describes space-saving Needle Valves for instrument lines, orifice meters, gages, by-passes, and fine regulation of gases and liquids.—Lunkenheimer Co., Cincinnati 14, Ohio.

CIRCLE 445 ON READER-SERVICE CARD

CONTROL VALVE. 2-page Bulletin SRM 709.22 describes diaphragm-actuated V5 Control Valve.—Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.

CIRCLE 446 ON READER-SERVICE CARD

VALVE OPERATORS. 12-page Bulletin 2000 describes totally enclosed automatic positioners that require no periodic lubrication, prevent valve operator overtravel during manual or automatic operation.—Harold Beck Co., 3640 N. 2 St., Phila. 40, Pa.

CIRCLE 447 ON READER-SERVICE CARD

VALVE APPLICATIONS. Series of 10 Application Guides include information on hot water temp control for tall buildings, storage heaters; main valve selection steam service; motor-operated shut off, etc.—Spence Engr. Co., Inc., Walden, N. Y.

CIRCLE 448 ON READER-SERVICE CARD

COUNT, TIME

DIGITAL COUNTERS. 20-page catalog describes high-speed solid-state and vacuum tube electronic counters, timers, preset counter-controllers, decade counters, etc.—Computer Measurements Co., 12970 Bradley Ave., San Fernando, Calif.

CIRCLE 449 ON READER-SERVICE CARD

TIMER. 4-page brochure describes Micro-Adjustable Sequence Timer Model 4-23.—Technology Instrument Corp., Space Instrumentation Div., 533 Main St., Acton, Mass.

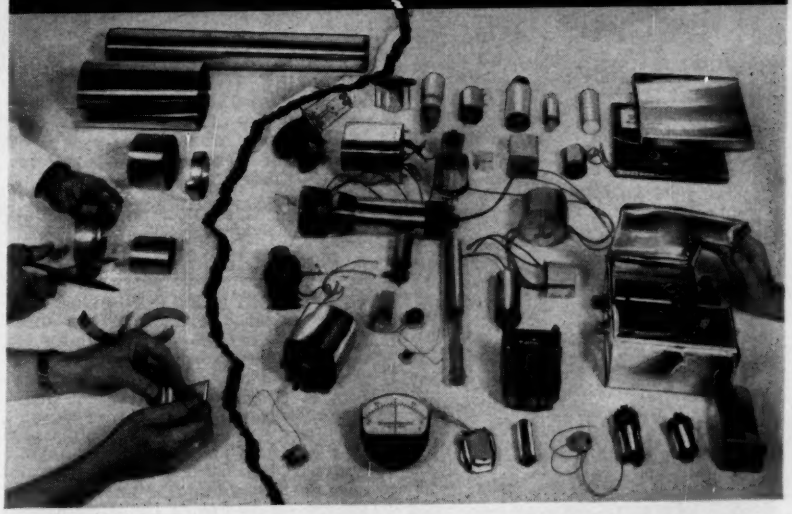
CIRCLE 450 ON READER-SERVICE CARD

WRAP-AROUND MAGNETIC SHIELDS

APPLIED IN SECONDS

Economical CO-NETIC & NETIC Magnetic Shielding Foils

For Any Size or Shape Components



Netic and Co-Netic foils are universally used as an evaluation tool; ultimately, as a production solution. Available in continuous lengths on rolls up to 15" wide . . . for human production line or to fit automated existing reels of your tape serving machinery. Furnished in final annealed state ready for your operation.

HOW YOU SAVE SPACE, WEIGHT, TIME, MONEY

Minimum weight and displacement shielding designs are possible due to the magnetic shielding effectiveness of Co-Netic and Netic foils . . . foils can be supplied FROM .002", even thinner if you desire. Ordinary scissors cut foil easily to exact contour and size required. Foil can be wrapped quickly around hard-to-get-at components, saving valuable time, minimizing tooling costs.

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Guard against performance degradation from unpredictable magnetic field conditions to which your equipment may be exposed. Eliminate such failure or erratic performance possibilities with dependable Co-Netic and Netic protection . . . assuring *performance repeatability* for your device over a *wider range* of magnetic field conditions.

Co-Netic and Netic alloys are not affected significantly by dropping, vibration or shock. They are characterized by low magnetic retention and do not require periodic annealing. When grounded, they effectively shield electrostatic as well as magnetic fields over a wide range of intensities.

Every satellite and virtually all guidance devices increase reliability with Netic and Co-Netic magnetic shielding alloys. Use these highly adaptable foils for saving valuable space, weight, time and money . . . in solving your magnetic shielding problems for military, commercial and laboratory applications.

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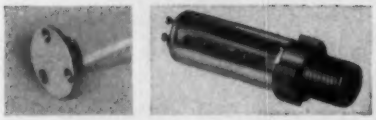

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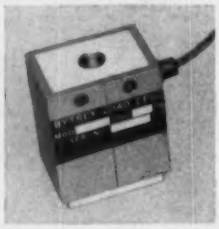

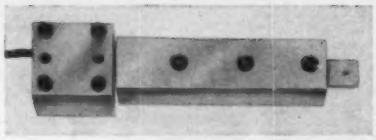

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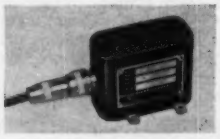

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CIRCLE 178 ON READER-SERVICE CARD

ELECTRONIC TIMERS. 4-page Fact File Folder describes time delay relays, electronic timers, pulse generators and flashers.—Slip Ring Co. of America, Electronic Timer Div., 3612 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 451 ON READER-SERVICE CARD

TIMERS. 4 bulletins describe Model 1039 10-Mc Counter-Timer, Model 1043 RDB Counter, Model 1031 Mc-Microsecond Counter-Timer, Series 200 Digital Voltmeters.—Systron Corp., 950 Galindo, St., Concord, Calif.

CIRCLE 452 ON READER-SERVICE CARD

RECYCLING TIMER. 2-page Bulletin 501 describes Dual-Trol timers, which produce series of "on" and "off" electrical pulses, time settings from 6 sec to 3 hr.—Industrial Timer Corp., 1407 McCarter Hwy., Newark 4, N. J.

CIRCLE 453 ON READER-SERVICE CARD

TIME, COUNT

QUICK RESET COUNTER. 4-page Bulletin "Series 1591" describes quick-reset high-speed magnetic counter for remote indication of equipment operation.—Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.

CIRCLE 454 ON READER-SERVICE CARD

ELECTRONIC COUNTERS. 6-page Short Form Catalog illustrates and specifies 17 types of counters and/or timers.—Erie-Pacific Div. Erie Resistor Corp., 12932 South Weber Way, Hawthorne, Calif.

CIRCLE 455 ON READER-SERVICE CARD

COUNTERS. 2 data sheets describe bi-directional differential impulse counters from stock.—Presin Co., Inc., 2014 Broadway, Santa Monica, Calif.

CIRCLE 456 ON READER-SERVICE CARD

PHOTOELECTRIC COUNTER. 2-page Bulletin "Series 1810" describes and illustrates a simple, low-cost, general purpose photoelectric counter.—Electronic Controls Div., Veeder-Root Inc., Danvers, Mass.

CIRCLE 457 ON READER-SERVICE CARD

ELECTRICAL COUNTER. 2-page Bulletin Series 1744 pictures and describes high speed electrical counter which records, displays, and transmits accumulated digital levels.—Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.

CIRCLE 458 ON READER-SERVICE CARD

STROBOSCOPE. 4-page Bulletin 781 describes Model 510-AL high intensity stroboscope.—Herman H. Sticht Co., Inc., 27 Park Place, New York 7, N. Y.

CIRCLE 459 ON READER-SERVICE CARD

ULTRASONIC SYSTEMS. 8-page bulletin describes inspection systems analytical equipment, transducers, and accessories.—Elion Ultrasonics, Inc., 430 Buckley St., Bristol, Pa.

CIRCLE 460 ON READER-SERVICE CARD

LEVEL, LIQUID

LEVEL CONTROLS. 4-page brochure describes high stability TEKTOR®, which is accurate and sensitive up to 250' from sensing probe for liquid, solid or powder level control.—Fielden Electronics, Inc., Huntington, N. Y.

CIRCLE 461 ON READER-SERVICE CARD

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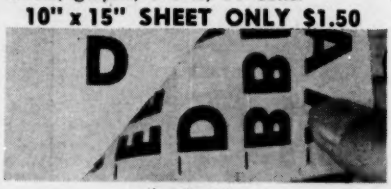

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CIRCLE 180 ON READER-SERVICE CARD

LIQUID DETECTION. Technical Bulletin 2650 and Special Product Note 2770 describe universal Liquid Detection System which uses electronic unit to detect presence, or absence, of virtually any low viscosity fluid, including liquid hydrogen.—Trans-Sonics, Inc., Box 328, Lexington, Mass.

CIRCLE 462 ON READER-SERVICE CARD

VISCOSITY CONTROL. 2-page Bulletin V-1225 describes system for flexographic and rotogravure printing, and for all types of finishing applications. —Norcross Corp., 247 Newtonville Ave., Newton 58, Mass.

CIRCLE 463 ON READER-SERVICE CARD

LIQUID DENSITY. 6-page brochure describes Qualicon Gages that measure and control solution and slurry densities without contacting material and without moving parts.—Nuclear-Chicago Corp., 333 E. Howard Ave. at Nuclear Dr., Des Plaines, Ill.

CIRCLE 464 ON READER-SERVICE CARD

SILICONE FLUIDS and their applications as hydraulic and damping fluids, dielectrics and lubricants, antifoam agents, coatings, etc. are presented in 20-page Data Book S-9.—General Electric Co., Waterford, N. Y.

CIRCLE 465 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

SCIENTIFIC & TEST INSTRUMENTS. 48-page Catalog G-10b describes and prices Amplifiers, Data Handling Systems, Oscillographs, Electronic Medical Systems, Recorders & Indicators, etc.—Minneapolis-Honeywell Regulator Co., Station M389, Wayne & Windrim Aves., Phila. 44, Pa.

CIRCLE 466 ON READER-SERVICE CARD

SURFACE FINISH. 6-page catalog folder describes Surfindicator, portable instrument for measurement of surface microfinish on metal, plastic, glass, etc. regardless of shape or composition.—Brush Instruments, Div. Clevite Corp., 37th and Perkins, Cleveland 14, Ohio.

CIRCLE 467 ON READER-SERVICE CARD

RECORDER. 4-page Bulletin 6101 describes Model 602 2-channel Recorder with 6"-wide chart.—Esterline Angus Instrument Co., Inc., Box 596, Indianapolis 6, Ind.

CIRCLE 468 ON READER-SERVICE CARD

SOUND SURVEY METER. 2-page Bulletin K18C describes hand-held Type B transistorized Sound Survey Meter. —Korfund Co., Inc., Acoustics & Instruments Div., 35A5 Cantiague Rd., Westbury, L. I., N. Y.

CIRCLE 469 ON READER-SERVICE CARD

RADIATION COUNTERS. 2-page Bulletin DS describes two high-speed scalers for radiation counting in clinical, industrial and nuclear research. —Nuclear Measurements Corp., 2460 N. Arlington Ave., Indianapolis 18, Ind.

CIRCLE 470 ON READER-SERVICE CARD

ELECTRONIC INSTRUMENTS. New 1961-62 catalog details Electrometers, Micro-microammeters, Microvoltmeter, Regulated High Voltage Supply and High Megohm Bridge.—Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio.

CIRCLE 471 ON READER-SERVICE CARD

TELEMETERING. 4-page bulletin describes Model 5000 silicon transistorized FM-FM telemetering or accelerating systems.—Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif.

CIRCLE 476 ON READER-SERVICE CARD

DATA HANDLING

COMPUTER COMPONENTS. 4-page Bulletin AC-6030 describes TR-5 Mounting Units and PACE Solid State Analog Computing Components that can be combined in wide variety to perform diversity of computing functions.—Electronic Associates, Inc., Long Branch, N. J.

CIRCLE 477 ON READER-SERVICE CARD

COMPUTERS. 4-page brochure describes LP-2000 Linear Programming System; 12-page brochure presents features of new Philco 2400 Data Handling System.—Marketing Dept., NP, Computer Div., Philco Corp., 3900 Welsh Rd., Willow Grove, Pa.

CIRCLE 478 ON READER-SERVICE CARD

DATA COMMUNICATOR. Bulletin BSP-05611 describes Model DC-11 module which allows expansion of G-20 Computer System, permits simultaneous read-write-compute with input/output impedance.—Bendix Computer Div., Bendix Corp., Los Angeles 45, Calif.

CIRCLE 479 ON READER-SERVICE CARD

COMPUTER TAPES. Spec sheet and price list give information on six control tapes for use in programming applications with high speed photoelectric or electro-mechanical readers; include new thinner tape providing 2700' which fits on standard 10" tape reels.—Lamcote Div., Arvey Corp., 3500 N. Kimball Ave., Chicago 18, Ill.

CIRCLE 480 ON READER-SERVICE CARD

CARD READERS. Brochure and 4 data sheets describe Punched Card Sensors having from 50 to 1500 switches.—Taurus Corp., Academy Hill, Lambertville, N. J.

CIRCLE 481 ON READER-SERVICE CARD

DIGITAL MODULES. Selection Chart A-701 lists Laboratory and System Modules.—Digital Equipment Corp., Maynard, Mass.

CIRCLE 482 ON READER-SERVICE CARD

DIGITAL INSTRUMENTS. 4-page Catalog 19-92 details dc, ac/dc digital voltmeters, preamplifiers, scanners and readouts.—Kin Tel Div., Cohu Electronics, Inc., 5725 Kearny Villa Rd., San Diego 12, Calif.

CIRCLE 483 ON READER-SERVICE CARD

AC-DC CONVERTER. 2-page Bulletin PIR848-1 describes Model 49.001 unit that provides readings accurate to 0.05% of full scale.—Electronic Associates, Inc., Long Branch, N. J.

CIRCLE 484 ON READER-SERVICE CARD

CONVERTER. 12-page bulletin includes data sheet and technical report on Capcoder, capacitive charge transfer an/dig converter.—Towson Labs., Inc., 200 E. Joppa Rd., Baltimore 4, Md.

CIRCLE 485 ON READER-SERVICE CARD

GAS ANALYSIS CELLS. 2-page Bulletin TRC-461 describes TR-III Series Temperature Controlled Cell Assemblies.—Gow-Mac Instrument Co., 100 Kings Rd., Madison, N. J.

CIRCLE 486 ON READER-SERVICE CARD

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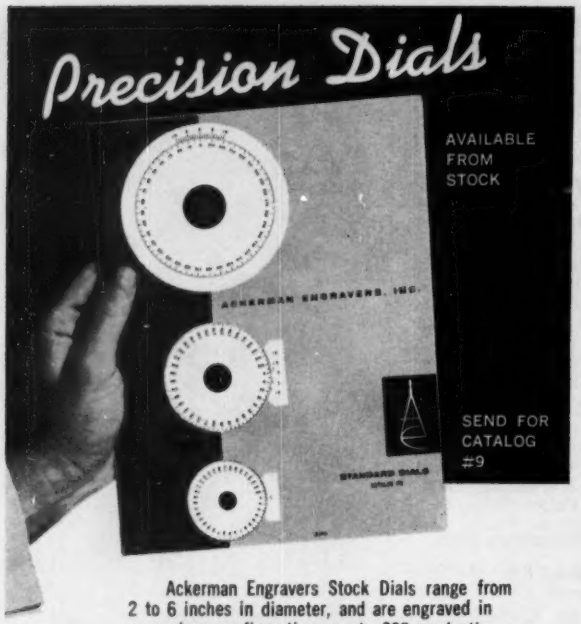

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CIRCLE 198 ON READER-SERVICE CARD

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CIRCLE 143 ON READER-SERVICE CARD

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ANALYTICAL

ANALYSIS. 4-page bulletin describes Electron Spin Resonance Spectrograph, Electrospec*200, for observation, monitoring and recording of E-S-R signals.—Elion Instruments, Inc., 430 Buckley St., Bristol, Pa.

CIRCLE 487 ON READER-SERVICE CARD

ANALYTICAL INSTRUMENTS. 28-page catalog contains specs and data on Electron Probe Micro-Analyzers; Automatic, 122-KV Constant Potential, Portable, and Standard Vacuum X-ray Spectrographs; X-ray Diffractometers, X-ray Diffraction Units and Cameras.—Philips Electronic Instruments, 750 S. Fulton Ave., Mount Vernon, N. Y.

CIRCLE 488 ON READER-SERVICE CARD

PANEL METERS

PANEL INSTRUMENTS. 6-page Bulletin 01-111 presents 2½" and 3½" Series 201/301; 6-page Bulletin 01-113 provides specs on 4½", 5½", and 7½" Series 1900.—Daystrom, Inc., Weston Instruments Div., 614 Frelinghuysen Ave., Newark 12, N. J.

CIRCLE 489 ON READER-SERVICE CARD

PANEL METERS. Data Sheets cover new Style 42 (4½" rectangular) and Style 65 (4" x 6") panel meters.—Helipot Div., Beckman Instruments, Inc., Fullerton, Calif.

CIRCLE 490 ON READER-SERVICE CARD

BEZELS. 2-page Bulletin 112 illustrates and describes new annunciator snap-on window bezels.—Panellit, Div. ISI Inc., Skokie, Ill.

CIRCLE 491 ON READER-SERVICE CARD

MISCELLANEOUS

CLOSED CIRCUIT TV. 8-page Catalog 6-205 presents features and applications of Automatic Closed Circuit TV Systems.—Kin Tel Div. of Cohu Electronics, 5725 Kearny Villa Rd., San Diego 11, Calif.

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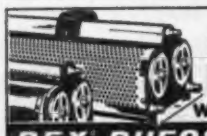

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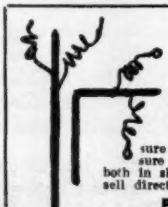

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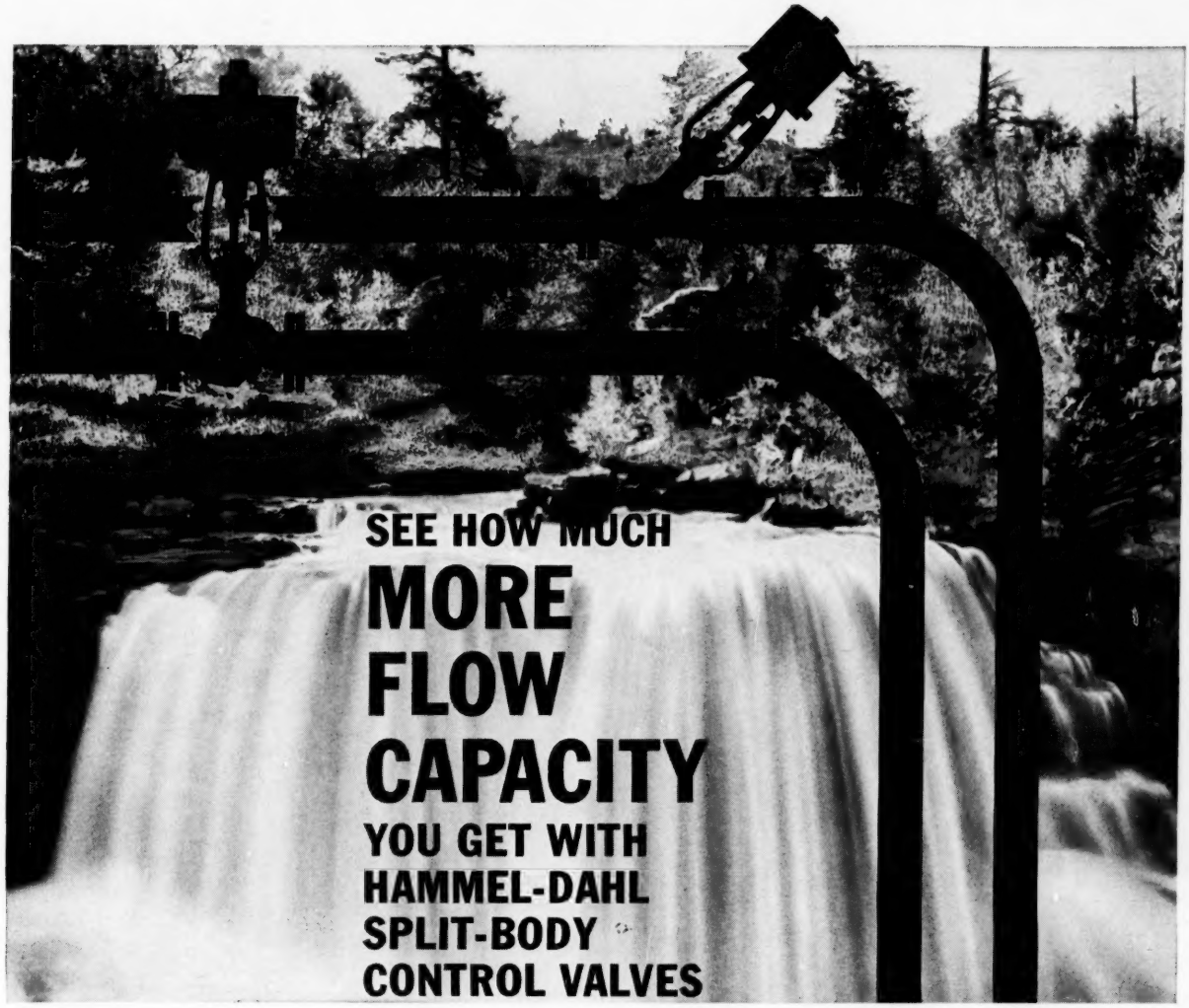

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1"	12	13	18	20	1"
1½"	26	33	50	60	1½"
2"	45	50	100	105	2"
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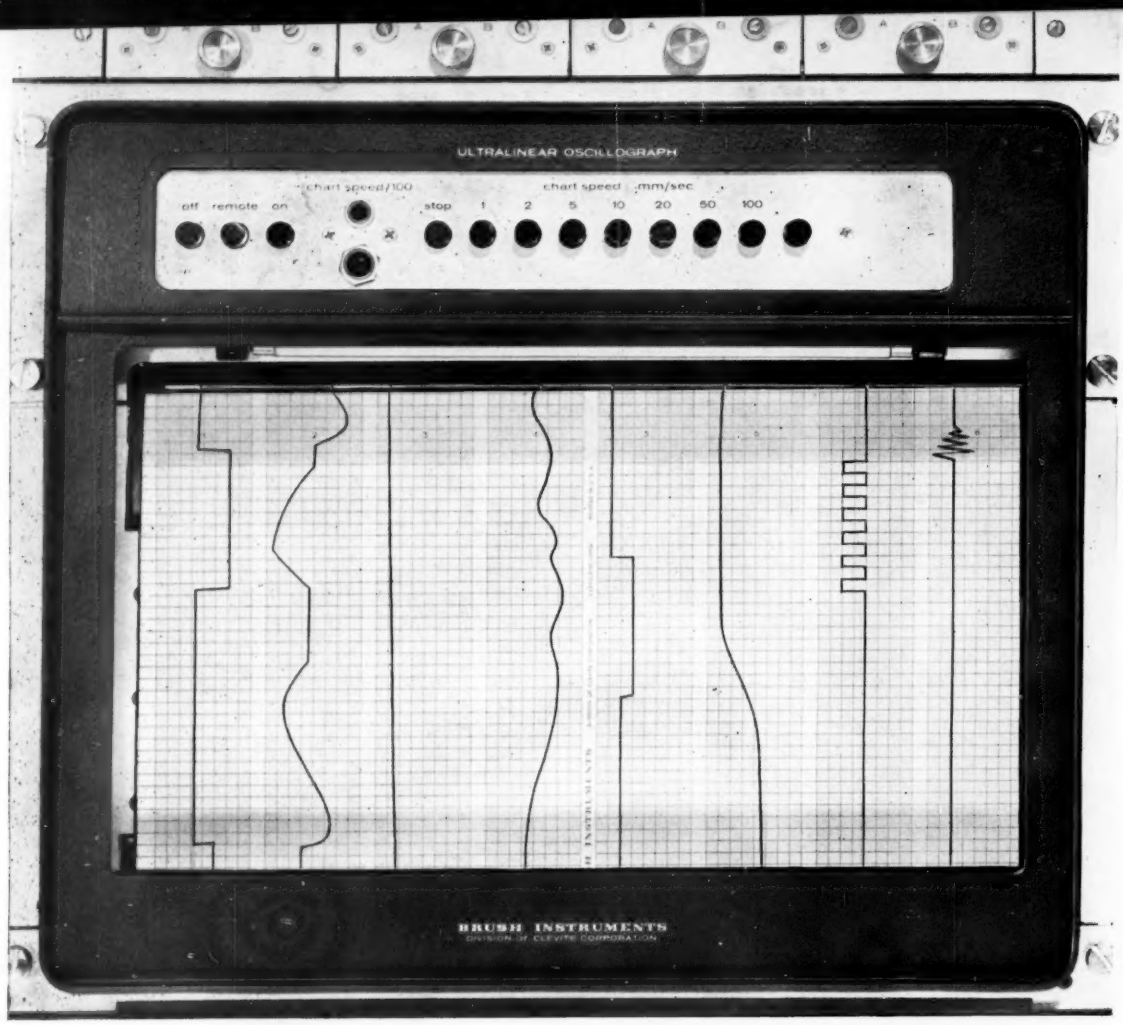

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